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The Relation of Impure Water to Disease.

SEE ANNOUNCEMENT, PAGE VIII.

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Volume XVIII. MARCH and APRIL, 1897. Numbers 3 and 4.

'Ασφαλὲς καὶ ἔμπεδον ἔστω τὸ σὸν ἕδος. 'Εκ σκότου μὲν ἔξαγε φάος, ἐκ δὲ πάθους ἀναψυχήν.

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ALBANY MEDICAL ANNALS.

VOLUME XVIII. MARCH AND APRIL, 1897. NUMBERS 3 AND 4.

Original Communications.

A DISCUSSION ON THE RELATION OF IMPURE WATER TO DISEASE AND THE CURE AND PREVENTION OF THE LATTER,

HELD AT THE ANNUAL MEETING OF THE MEDICAL SOCIETY OF THE STATE OF NEW YORK,

JANUARY 28, 1897.

ORGANIZED BY HENRY HUN, M. D., ALBANY, N. Y.

INTRODUCTION.

BY HENRY HUN, M. D.,

Albany, N. Y.

When the President of the Medical Society of the State of New York, Dr. Spencer, requested me to organize a discussion to be held at the annual meeting of the society in 1897, no topic appeared to be more opportune than the relationship of contaminated water to disease. A great deal of investigation had been made on this subject during the past twenty years, and many important facts concerning it had been established on a firm basis; if in a series of brief, practical papers, written by men actively engaged in research and study, these established facts could be plainly presented to physicians from all parts of the State at the annual meeting of its legal and representative Medical Society, it seemed likely that good would result.

In such a discussion, the first question presenting itself must be: What diseases can be directly traced to contaminated water, either used as drinking water or in other domestic uses? And next would naturally present themselves the questions, how water becomes contaminated, how this contamination can be prevented, and how contaminated water may best be purified. Within the limits of these questions the discussion might well have been confined, but in that case its interest would have been restricted mainly to bacteriologists, health officers and sanitarians. The membership of the State Society consists mainly of practicing physicians engaged in the routine work of their profession, and, to awaken a more general interest, it seemed wise to add some consideration of the most important disease caused by contaminated water — typhoid fever. For this reason, topics on the life history of the typhoid germ outside the body, the importance and practical methods of disinfection of excreta of typhoid patients, and some points in the treatment of the fever, were added. Finally, the discussion was completed by a consideration of the bacteriological diagnosis of typhoid fever, in which during the past year most substantial progress has been made, and by a discussion on the occurrence of typhoid fever in young children, in regard to which much difference of opinion exists at the present time.

It speaks well for the earnest zeal of the medical profession in the State that, almost without exception, every one whose co-operation in this discussion was requested willingly undertook the labor of preparing the respective papers, for which I return them my most hearty thanks, and I am greatly pleased that the papers can be published together in one number of this journal, and be distributed very widely among sanitarians and others interested in this subject. There are few cities in this State and country in which the water supply is not a subject of anxious consideration; the rapid increase in population having rendered older and simple methods of procuring this supply dangerous. It is to be hoped that this discussion may be of service in helping to solve some of these problems, and, where they are badly solved, in helping to restore those suffering from typhoid fever to health, and in preventing the spread of this common but preventable disease.

I. COMMON CAUSES OF THE CONTAMINATION OF DRINKING WATER.

BY TIMOTHY MATLACK CHEESMAN, M. D.,

Instructor in Bacteriology, College of Physicians and Surgeons, Columbia University, New York.

Water is a transparent, inodorous, tasteless fluid, composed of hydrogen and oxygen.

All water found in or upon the crust of the earth is derived from the watery vapor of the atmosphere. This vapor becomes condensed, and falling to the earth, a certain portion of it moistens the soil and sinks into it some depth, following the spaces between the small grains of which the surface layers of soil are composed, and when these interstices become filled up a considerable amount of the precipitated moisture runs off from the puddles which collect here and there, through little rivulets formed by the force of the water, and seeks some lower level where it can soak into other soil ; or it reaches some water-course and is carried by the brooks, creeks and rivers out into the sea.

It has been estimated that only about two-thirds of the water which falls during a shower or rain-storm follows the course that has been indicated here; the remaining one-third is soon taken up by the atmosphere again in the form of watery vapor. This moisture mingles with the large mass of watery vapor derived from the ocean and in due time is again precipitated in the form of rain, snow, hail, frost and dew.

As is well known, the atmosphere is a mechanical mixture of gases, nitrogen and oxygen being normally present in fixed proportions; and other gases, such as carbon dioxide, ammonia, ozone, etc., are found in varying amounts. In this aëriform fluid which surrounds the earth is also found a large quantity of dust.

Dust is organic or inorganic matter so finely divided that it may be caught up and carried by a gentle wind, and is largely a product of human activity. It is derived almost exclusively from waste substances, and for this reason cannot always be looked upon as harmless.

Now, when the moisture in the air is condensed into water, it takes up in solution certain of the gases from the atmosphere, and in its rapid fall to the earth drags down many of the minute suspended

particles of matter, *i. e.*, dust, with which it comes in contact. On reaching the surface of the earth it again becomes mixed with other organic and inorganic matters which are found there, part of which it takes up in solution and part it carries along with it in suspension. The action of this water as a solvent for many of the substances with which it comes in contact is greatly increased by its holding certain gases in solution, and if we could accurately trace the wanderings of the water which falls in a summer shower and follow the chemical changes which it undergoes, here dissolving compounds with which it comes in contact, and there precipitating compounds which it has formed, we would doubtless have a much better understanding of the composition of many of our water supplies.

Many of the suspended matters carried along by waters which course upon the surface may become water-soaked and sink ; others again are thrown upon the shores by the current, or driven there by the wind, and are thus removed from the water, or may, if small and buoyant, remain suspended in the water for an indefinite time and be carried almost any distance.

The water which sinks into the soil also takes up many substances in suspension and in solution. The larger of the suspended matters are removed mechanically, and the smaller, even the very smallest, are gotten rid of by filtration, and cling to the slimy film which forms upon the little grains which compose the surface soil. The chemical composition of the water is also changed materially as it penetrates the soil, partly through the action of bacteria, which seize upon certain of the chemical elements in the compounds which are dissolved in the water, and partly by the solution of compounds which it is capable of taking up.

We have, then, two kinds of water to consider — the surface water, or that which is found upon the surface and which runs in brooks, streams and rivers or is confined in hollows, forming ponds and lakes ; and the ground water, or that which enters the soil, sinking deeper through the pores, or along fissures and faults of the more superficial of the earth's crust until it is stayed by meeting some impermeable stratum of rock or clay. Here it rests, forming bodies of water of greater or less extent, which correspond to the lakes and ponds on the surface, and these often communicate with each other through underground streams and break upon the surface as springs.

The composition of these waters usually differs very considerably. Surface waters, coming in contact with fewer of the mineral ingre-

dients of the soil, are apt to be more free from mineral matters in solution than are the ground waters, and it is on this account that a soft water is more likely to be found among the surface waters, and a hard water among the ground waters. Surface waters, on the other hand, are more likely to contain suspended matters than are the ground waters, because from these latter even the smallest particles are removed by proper filtration through the soil.

It is usually not a particularly difficult matter to find out by chemical analysis the kinds of substances which are in solution and their amounts, and from the results obtained to determine whether or not the water under consideration holds in solution anything which is poisonous.

After this determination has been made, it becomes most important to discover whether harm can come from any of the particles which are in suspension, and this is a most difficult thing to do. Suspended matters which are not living there seems to be no cause to fear, but we know surely that there exist among the smallest living things of which we have any knowledge certain plants and animals, called germs, microbes, or micro-organisms, which, entering the animal body, may multiply there, and in one way and another give rise to disturbances of the normal functions and produce disease.

The forms of micro-organisms whose life history we understand the best are the bacteria, which are classed among the microscopic plants, and from the study of the bacteria it has been learned that certain of those which are capable of producing disease, *i. e.*, the pathogenic species, may live for long periods of time and, under certain conditions, multiply enormously in water. Further, there is good reason for believing that these pathogenic bacteria to which we refer have no normal habitat in water or in soil, but are derived solely from the bodies of those suffering from the disease in question. These bacteria may be present in any of the body excretions, but are found most surely and most abundantly in the bowel discharges.

There seems to be abundant ocular demonstration of the fact that many otherwise potable waters are sewage polluted, and it does not require a great stretch of the imagination to believe that at times some of the sewage poured into the water may contain the undisinfected discharges from patients suffering from one or other of the infectious diseases which are caused by certain of these bacteria.

As yet, no practical analysis or test has been devised by which

pathogenic bacteria can be surely detected when present in water or sewage.

Chemic analysis of water does not assume to help in isolating or identifying any kind of bacteria. For this purpose the methods used for the study of the bacteria must be employed, and the enormous number of species found, the numerous and tedious tests required for the identification of any species, and the improbability of finding, in a living condition, the particular pathogenic species sought for, in the minute quantity of the sample which can be used for this analysis, render the search for pathogenic bacteria in water or in sewage almost a hopeless one in the beginning, and usually a fruitless one in the end.

I think it is pretty well established that water derived from uninhabited regions is harmless, so far as the presence of pathogenic bacteria is concerned, and it is only a water which has become infected, either directly or indirectly, with micro-organisms derived from the bodies of those suffering from infectious disease that we have any cause to fear.

Now, since it seems to be proven that the great majority of pathogenic bacteria which are likely to be water carried are voided from the system with the bowel discharges, and these discharges are found most commonly in sewage, it is a sewage-polluted water that is most likely to be the carrier of infection.

It is not to be supposed for an instant that any water, however contaminated it may be, or even sewage itself, is teeming with pathogenic bacteria. The pathogenic organisms are to be found only in very inconsiderable numbers compared with the other bacteria which may be present, and gallon after gallon of the infected water may be drawn and used, which is entirely free from the danger which may be present in the cup of water we drink. Drinking diluted sewage is by no means necessarily harmful, but certainly it is fraught with danger because of its liability to contain germs of disease.

In inhabited regions, surface waters and the more superficial of the ground waters, such as are found in shallow wells, are usually exposed, in a greater or less degree, to sewage contamination, either through ignorance or carelessness of the inhabitants or their wanton neglect of certain of the most obvious rules of sanitary science.

The improper disposal of sewage, whether by emptying it into streams, or hiding it in cesspools, practices which may be observed

among refined and civilized people, which seem to have as their aim the removal of the effete products of human life from the vicinity of their begetting, no matter what may become of them, are definite sources of danger to the public health.

In many localities this improper disposal of sewage seems to be the rule, rather than an exception, and I am, therefore, convinced that unpurified waters from the neighborhood of populated districts are to be looked upon with suspicion.

If we suppose that a water has been obtained which has thus far safely run the gauntlet of infection, or a water that has been adequately purified, it is not at all impossible that it may become seriously contaminated before it reaches the consumer.

As we well know, for convenience, water is stored in small bulk, to be drawn upon when needed. The cisterns or tanks used for storage are often made of some indestructible material, such as iron, which is not infrequently galvanized to prevent rust, or of copper, which may be tinned to avoid its corrosion, or of lead, which often is not lined at all, and the inlet and outlet pipes are frequently made of lead, and minute quantities of these metals may be dissolved by the water and cause acute or chronic mineral poisoning.

These dangers, however, are usually transitory, as a scum of vegetable growth soon forms upon the surfaces of the tanks and pipes in which water is confined, and thus prevents the water from coming in contact with or acting upon the metals.

A much greater source of danger comes from the presence of organic matter in the cistern, matter which is present in almost every water-supply at some seasons of the year, and which is carried in suspension in the water, settles to the bottom of the tank and there remains as a food supply for the bacteria. Many of the saprophytic bacteria are very hardy and can live and multiply under conditions which would be impossible for the more vulnerable pathogenic species, but under favorable conditions of temperature, protected from light, abundantly supplied with air and in a fluid charged with organic matter, even pathogenic bacteria will multiply enormously. These conditions are to be found in many of the tanks which supply our houses, many of them may not have been cleaned out for years, others more or less thoroughly cleaned once a year, and then, perhaps, only under protest, by order of the health authorities. Such tanks are often built so that it is impossible to clean them properly, and some are so placed that it is next to impossible to get at them to clean them at all.

The presence of a single pathogenic micro-organism in such a cistern might result in its active multiplication and in a serious outbreak of disease.

Water-coolers are cisterns on a smaller scale, but are much more liable to infection from sources outside of the water itself, as they require to be filled more often.

The frequent draught upon a water-cooler, which may be observed, for instance, in a railroad car on a warm summer day, soon results in its exhaustion. If a new supply is called for, the accommodating brakeman may, at some station, obtain it from an unusual source and fill the cooler with water, the purity of which he does not know and perhaps does not consider, carrying it in a bucket the cleanliness of which he has not time to discover. The cleanliness of the cooler itself is a very important matter. It is possible that, although these receptacles are frequently emptied, they may seldom be thoroughly cleansed, and if this be so, the slimy vegetable coating which lines it may prove a lodging place for any infectious material which has entered it, and will supply the nutriment which will enable it to produce many generations of its kind.

Dirty hands, the use of dirty cloths or receptacles for carrying or storing the water or the ice, ice which has in one way or another become infected, and sometimes even dust, may prove serious sources of danger in contaminating a water which has previously been most carefully purified.

My experience teaches me that the danger from infected hands is a very real one, as on three or four occasions I have isolated the B. coli communis, an organism found normally in the intestinal discharges of man, from bits of epidermis scraped from the fingers. These organisms are not pathogenic, but they were in all probability obtained from contact with the dejecta, a source from which bacteria which may produce disease are often derived.

Ice formed from sewage-polluted water is a well known source of danger, and even artificial ice is not always entirely safe, requiring human interference in its preparation, as I had the opportunity on one occasion to observe, while trying to demonstrate the relative purity of clear artificial ice. One of the plates under examination contained so many colonies of one particular kind that I had the organism carefully studied, and found that it corresponded biologically with the staphylococcus pyogenes aureus. This organism was lost before its pathogenic properties were determined, but there is no

doubt in my mind of its identity with the golden pus coccus. My explanation of its presence in the ice is that the cans were handled by someone having a suppurating wound, and thus caused the infection.

Although there are many sources of contamination, which can only be suggested here, which may lead to the infection of water with pathogenic bacteria, I am not unmindful of the fact that there are ways in which most of these dangers may be avoided. It is most important to obtain a full knowledge of the dangers that exist, and then by the exercise of an intelligent vigilance to avoid them.

46 East 29th Street.

II. DISEASES WHICH CAN BE DIRECTLY TRACED TO CONTAMINATED DRINKING WATER.

BY GEORGE BLUMER, M. D.,
Director of the Bender Hygienic Laboratory, Albany, N. Y.

In order to prove with certainty that a given disease can be, or in a given instance is, caused by drinking water, we must bring evidence to bear out the following postulates :

1. That the cause of the disease can be isolated from the water.

2. That the great majority of the individuals attacked by the disease partook of the water.

3. That there is no other source of infection common to all the individuals attcaked.

Points not absolutely necessary for proof, but strongly bearing on its probability, can be added to these postulates. The discovery that the suspected water had actually been exposed to contamination from the given disease shortly before an epidemic would be one of these. The fact that individuals who were not exposed to the suspected water escaped infection is, of course, implied in the second postulate. The diseases which are under discussion are those which it is generally assumed can be carried by contaminated water. Some of them, you will find, will stand the test of the above postulates, others will not. All of the diseases can come under one of two main categories; either they are caused by mineral contaminations, or they are the result of the presence of living organisms.

The diseases caused by mineral contamination are of such infrequent occurrence in this country, and of such secondary importance,

that they will be merely touched upon. It is hardly necessary to say that they stand the test of rigid investigation, as the substances causing them are almost all easily detected by chemical examination, even in very small quantities, and hence they are found with ease, both in the contaminated water supply and the affected individuals.

By far the most common mineral contamination of drinking water is lead. It is particularly apt to contaminate the water in regions where this passes through peaty soils, and absorbs acids therefrom, but may occur as the result of any acid water acting upon lead water pipes, and forming salts of lead. A number of epidemics of water-born lead poisoning have occurred, the most extensive being that mentioned by Oliver, in which over 600 individuals were affected. Other harmful mineral substances are very rarely found as a contamination of drinking water, though it is interesting to note that certain spring waters contain such large quantities of sulphate of magnesia and soda that they have given rise to epidemics of diarrhoea.

The diseases due to water contaminated by living organisms can be again subdivided into those caused by animal and those caused by vegetable organisms. Under the first heading come the two diseases malaria and amœbic dysentery. At the very outset we find that in these diseases we cannot prove the first postulate; we cannot isolate either the cause of malaria, or the cause of amœbic dysentery from drinking water; and further than this, we do not know the natural habitat of either of the organisms. It is unnecessary to state that there are many who believe in the water-borne origin of malaria,* and, indeed, a casual examination of the literature on this subject would lead one to believe that the disease is frequently transmitted in this way. Close study of the literature, however, shows that there is but little reliable evidence in favor of it, and much against it. Aside from the fact above stated, that we do not know the natural habitat of the malarial organism, we find that for this disease there is another infective factor besides water, which is common to all exposed, and that is air. A further hindrance to the clearing up of the subject is the fact that in the great majority of reported instances of water-borne malaria, no satisfactory differentiation is made between malaria and typhoid fever, and, in fact, many of the reported cases give to the unbiased mind the impression that they

*I am indebted for much of the above information concerning malaria to the editor of the *Johns Hopkins Hospital Bulletin*, who kindly allowed me to have the advance sheets of an article by Dr. Rupert Norton, of Washington, D. C., "Is Malaria a Water-borne Disease?"

are typhoid rather than malaria. The outbreak of malaria which is almost always cited as the one which proves most conclusively that the disease can be water-born is that which occurred on the ship "Argo." The epidemic in question occurred in a band of soldiers being carried on the ship between Algeria and Marseilles. In the short voyage between the two points, 13 out of 120 soldiers died, and on arrival 90 men were brought ashore sick, showing, according to Boudin, who reported the epidemic, marked symptoms of malarial intoxication in all its forms. The sailors on the same ship were absolutely free from disease, and on investigation it was found that whilst the sailors were using pure drinking water, the soldiers were using some water which had been taken from a well, in a marshy district, just before the sailing of the ship. The reporter naturally concluded that the water in this instance was the infecting agent. The weak points in the story are, first, that no mention is made of the length of the voyage, so that we get no idea of the duration of the attacks of fever; second, that it is not stated whether the soldiers went ashore at Boné, where the marsh water was procured. Moreover, the report states that many of the attacks of fever were continuous and were not influenced by quinine, and furthermore, the author himself states that his evidence is not conclusive. If this is the most conclusive report in favor of the water-born origin of malaria, what must we say of the other less conclusive ones? The facts against the transmission of malaria by water are, on the other hand, quite conclusive. Celli, a well-known Italian observer, gave healthy individuals large quantities of water from the Pontine marshes, which are acknowledged malaria-breeding grounds, and in no case did malaria result. Another Italian observer, Salamone-Marino, gave 5 to 24 litres of marsh water from a malarious country daily, for from 6 to 24 days, and did not succeed in a single instance in producing malaria. Moreover, it has been frequently noted that persons may live in a malarious district and drink pure water, and yet have malaria, whilst others in the same district may drink marsh water and have no malaria.

The evidence of water transmission in amœbic dysentery is almost as unsatisfactory as in malaria, but here the probabilities are in favor of a drinking water origin. Almost all the writers on the subject accord to impure water the chief role in its causation, though the only striking instance of a water epidemic is that mentioned by Quincke and Roos, in which 15 individuals were all taken with

dysentery after drinking from a siphon of artificial mineral water, amœbæ being found in the stools of one of them, who became the patient of these observers.

The diseases which have been most conclusively proven to be due to water infection belong to that class due to vegetable organisms, and are typhoid fever, cholera Asiatica, and certain diarrhœal diseases. Whilst not by any means holding that these diseases are always water-borne, we think that the evidence that they may be thus transmitted is absolutely conclusive.

With regard to typhoid fever, we meet with a stumbling block only in the proving of our postulate that the cause of the disease can be isolated from the water. This failure to isolate the typhoid bacillus from water is, however, due to certain biological peculiarities, for we know that the organism is capable of existing in water for some time. The researches of Grimbert and others have shown that, if a large quantity of a pure culture of the typhoid bacillus be placed in a flask of sterile water together with a relatively small quantity of a pure culture of the bacillus coli communis, at the end of a comparatively short time, varying from 24 to 48 hours, no typhoid bacilli can be isolated, they having been overgrown by the colon bacilli. It is this fact which acccounts for the observation, easily made, that in practically no well authenticated instance has the typhoid bacillus been isolated from contaminated water by competent observers in the last few years. The colon bacillus, being a normal inhabitant of feces, is, of course, discharged into the water with the typhoid in all cases of sewage contamination, and hence the difficulty in isolating the latter organism. The other postulates demanded as a proof of water transmission have been easily complied with in scores of typhoid epidemics, but only one such will be related. Perhaps one of the most striking examples of a water-borne typhoid epidemic was that which occurred in the Tees Valley in 1890–'91. This valley contains a population of about half a million people, the number being distributed about equally between the country districts and three large cities, which were the seat of the epidemic. The cities procured their water supply from the river Tees, the country districts from wells and smaller streams. The outbreak took the form of two distinct epidemics, each lasting about six weeks, and separated from one another by an interval of about six weeks. In the two outbreaks 1,463 cases occurred, 91 per cent. occurring in the three cities, and 9 per cent., some of which

were doubtless contracted in the cities, occurring in the country districts. The only possible contaminating agent common to all the cities, which lay at some distance from one another, was the drinking water, which came from the river. Investigation showed that this was exposed to all sorts of sewage contamination from towns and villages lying above the intakes of the cities. Moreover, it was shown that each of the two outbreaks reached its maximum just two weeks after a severe flood, showing that in all probability the direct cause of the outbreak was the sudden washing into the river of large quantities of refuse material.

Numerous other epidemics of water-borne typhoid might be cited occurring in this country and elsewhere, did time permit, and many of them as conclusive as the one just mentioned.

The disease which, as far as our postulates are concerned, can be most easily proven to be water-borne in many instances, is cholera Asiatica. Practically all of the violent and sudden outbreaks of this disease have had contaminated water for their origin, though it is admitted by all that, after the epidemic is under way, this is not the only means of spread.

Probably the most typical example of a water epidemic which has ever been published is that of the Hamburg cholera outbreak, so clearly described by Koch. The city of Hamburg has immediately adjacent to it two smaller cities, which, though continuous with it, have different water supplies. One of these is Wandsbeck, which is supplied with filtered lake water. The other is Altona, which receives filtered water from the Elbe below Hamburg. Hamburg itself, at the time of the epidemic, was supplied with unfiltered water from the Elbe, the intake lying just above the town. At the time of the epidemic mentioned, Hamburg was mainly attacked, the cities of Wandsbeck and Altona scarcely suffering at all, although under exactly the same conditions as Hamburg, except where water supply was concerned. The most striking results of the epidemic were seen where the cities of Hamburg and Altona joined. At this point there is a street, one side of which is supplied by Hamburg water, the other by Altona water. On the Hamburg side of the street there were many cases of cholera; on the Altona side none at all. Another striking fact was, that a group of houses in Hamburg, in a densely populated district, but supplied with Altona water, absolutely escaped; those about them, supplied by Hamburg water, being full of cholera cases. What makes the epidemic more instructive is the

fact that while the Hamburg people were drinking an unfiltered river water, which was apparently but slightly contaminated, the Altona people were drinking the same water, plus the entire sewage of Hamburg, during the whole epidemic, and yet escaped unharmed because their water was filtered.

While in this epidemic the cholera spirillum was not isolated from the water, yet numerous instances could be cited in which it was isolated in similar epidemics, and all the postulates of proof fulfilled. Such was the case in the epidemic at the Nietleben asylum described by Koch, and such was the case in a well epidemic which subsequently occurred in Altona.

Instances in which diarrhœal diseases, other than true cholera, have been traced to contaminated drinking water are very common. A well-marked example of such an epidemic is the so-called "block" epidemic, which occurred in Melbourne in 1892. In the last ten days of November of that year 50 per cent. of the individuals living in a certain block of houses in that city, and using tap water for drinking purposes, were taken with severe diarrhœa, with purging and passage of bloody stools. No other portion of the city was attacked, and in certain of the individuals who resided in the affected block, but used boiled water, only 1 per cent. were attacked. The outbreak was shown to be due to the cleaning of the water pipes supplying the block, during which cleaning a certain amount of foul liquid mud had been allowed to leak into the supply pipe by means of a defective valve. The bacteria causing diarrhœal diseases are certainly not constant, and are not yet thoroughly known, so that the isolation of a single characteristic organism from the water in all cases of water-borne diarrhœa could not be expected. Nevertheless there are numerous instances in which there have been found in drinking water bacteria which have been described as causing diarrhœa, particularly the organisms belonging to the colon group. In conclusion, it may be said that we have certain proof that Asiatic cholera, typhoid fever, certain diarrhœas and some forms of mineral poisoning may be carried by means of drinking water, probable proof that amœbic dysentery is carried in this way, and probable proof that malaria is not carried by drinking water in the great majority of instances. The deductions to be drawn from such conclusions are apparent to all, and may be briefly summed up in the statement that, if we do not have pure drinking water, we cannot expect a healthy community.

14 JAY STREET.

III. A STATISTICAL INQUIRY INTO THE RELATION BETWEEN CONTAMINATED DRINKING WATER AND TYPHOID FEVER.

BY JOHN S. BILLINGS, JR., M. D.,
Assistant Bacteriologist, New York City Board of Health.

A statistical inquiry into the relation between contaminated drinking water and typhoid fever, must be based mainly upon comparisons of death rates either of different cities, or of the same city at different times, with the character of the drinking water used, during or just prior to the periods for which the death rates are given.

It is difficult for one unfamiliar with the subject to realize the obstacles in the way of obtaining satisfactory statistics. Exact statistics on such a subject as the present one, are impossible to obtain. In most cases our results are only probable, and any conclusions drawn therefrom are only probabilities. It is in instituting comparisons that statistics are most valuable. As an absolute statement of fact, they are not to be relied upon; as a means of comparing two things, they are of great value and are also valuable as a means of obtaining averages.

In the statistics furnished by the various large cities we have to content ourselves with a knowledge of the number of deaths from typhoid fever monthly or annually. Of course, this gives no exact idea of the number of cases, as the mortality for different epidemics varies widely. But the relation of the number of cases to the number of deaths, in those large cities where the death rate from typhoid fever varies but little every year, is fairly constant, and we are justified in drawing conclusions from the death rates as to the relative prevalence of this disease.

In order to determine whether typhoid fever prevailing in a given locality is due to contaminated drinking water or not, we should first know whether the water is contaminated. The only sure means of determining this is, of course, a bacteriological examination of the suspected water for the typhoid bacillus. This is a tedious and difficult process, however, and is not regularly carried out by any of the boards of health of the various cities. They content themselves with a chemical examination of the water, the presence of certain abnormal constituents (the nitrites, etc.,) being taken as evidence of organic life and condemning the water as unfit for drinking purposes.

The fact of typhoid fever having a relatively long incubation period must also be taken into consideration, for by the time the disease manifests itself, the contamination of the water may have disappeared. This was well shown in Buffalo, where the supply of pure water running short, ordinary lake water was turned into the city water pipes for a short time. The number of cases of typhoid fever rose markedly about two weeks later, but by that time the water was perfectly pure again.

As a matter of fact, we have usually to content ourselves with showing that there is abundant opportunity for the drinking water of a given locality to become contaminated, and that when such contamination is prevented, the death rate from typhoid fever is markedly lowered.

Typhoid fever is a disease affecting by preference individuals of certain ages. In the United States census for 1890, the death rate from this cause was greatest among persons from 15 to 25 years of age. (78.69 per 10,000 of population.) So that in estimating the prevalence of typhoid fever in a given locality, we should know not only the total population of that locality, but also what number of that population fall into the different age groups; that is, whether there is a relatively large or small proportion of young adults in the community. Now it is only in the census year (once every ten years) that we can know the number of individuals in each age group for any given locality. And as statistics on this point have only been collected once (in 1890), we have no means of estimating what the number would be in any one of the following nine years. So that we are compelled to use the population figures for one year, and the number of deaths for a different year in order to compute our death rates,— a method which is obviously unsatisfactory. For example, an annual death rate from typhoid fever of 14 per 10,000 of population in one of the long established New England cities, such as Lawrence, Mass., where the number of young adults is relatively small, would signify a much greater prevalence of the disease than a death rate twice as high in one of the younger western cities, such as Denver, where the great majority of the population are young adults, and therefore susceptible to the disease.

The question of race must also be considered. The United States census for 1890 shows that the annual death rate from typhoid fever was more than twice as great among the colored as among the whites (127.86 for the colored to 59.41 among the whites). The question here comes up as to whether this increased mortality is not due to

habits of life, uncleanliness, etc. These undoubtedly play a part, for one great cause of the spread of typhoid fever is lack of proper isolation of the sick, and disinfection of the excreta; precautions which the negroes as a rule neglect entirely.

Among the white races the disease seemed most fatal to those of Scandinavian and Italian birth, and least so to the German and English. The fact that change of locality and use of a different drinking water render individuals more susceptible to typhoid fever, may have some influence. During the Centennial Exposition in Philadelphia in 1876, the death rate from typhoid fever was almost double what it was in former years.

The Germans substitute beer for water as a beverage to a large extent. This may partly account for the relatively low death rate among them from typhoid fever.

Sex does not seem to exert any influence.

The geographical locality must also be considered. The United States census for 1890 showed that typhoid fever was most prevalent in the southern central Appalachian region, the middle west, the plains and on the Pacific coast. The relatively large proportion of negroes in the south, and of Scandinavians in the northwest must here be taken into account.

The season of the year and the character of the seasons have also to be considered. It is well known that typhoid fever is a disease of the spring and autumn, the months of August, September and October being those in which we would expect to find the highest mortality from this disease. The character of the preceding summer has a marked effect upon the number of cases the following autumn. This was well shown in the autumn of 1892, when the mortality from this disease was high all over the country as a result of the preceding hot, dry summer.

A very important factor to be considered in the estimation of the prevalence of typhoid fever, is the number of immune individuals; that is of individuals who have had the disease once and are protected against a second attack. The immunity conferred by an attack of typhoid fever, while not as absolute as in the case of scarlet fever, measles and one or two other diseases, does exist, and in the vast majority of cases, protects against a second attack. This is explanatory of the fact that epidemics do not occur in localities where the disease has prevailed extensively in former years, and yet where the circumstances are such that one would expect to find the disease widespread. When the supply of epinosic individuals (mean-

ing by the term those susceptible to the disease) is exhausted, the disease disappears until a sufficient number of persons have come, by birth or immigration, into a locality to furnish a fresh supply. The disease must have fuel or it burns itself out. To this fact is due a certain appearance of periodicity in epidemics; which periodicity was formerly attributed to meteorological influences and other strange causes. A locality with a population containing a relatively large number of immune individuals, may be badly sewered or may have a badly polluted water supply, and yet show a relatively low death rate from typhoid fever. The case of Lawrence and Denver, cited above under the head of "Age," is an example of this. This fact of immunity explains why the greatest number of cases and the greatest number of deaths are not found in the dirtiest and most unsanitary portions of the city which are occupied by the lowest classes; and also why the death rate among those classes of men whose work is such as to constantly expose them to infection, is relatively low; sewer men, night laborers, etc. These people are all immune, and so the main ravages of an epidemic are among the better classes.

The question as to how these statistics should be collected will not be entered into here; suffice it to say, that as far as they go, the means adopted in the various large cities are fairly satisfactory.

The chief causes underlying the spread of typhoid fever are:

1. Impure water supply.
2. Imperfect drainage of a polluted soil.
3. Lack of isolation and disinfection of excreta, etc.

Under 1, we can further subdivide the causes into (*a*) the use of water from polluted wells, (*b*) springs, (*c*) running water, (*d*) lake water and, finally, (*e*) contaminated milk. This last comes under the head of impure water supply, as the contamination is due to the water used in the various dairy processes of washing the cans, etc.

Owing to the short time at our disposal to-day, no attempt will be made to go into the history of any of the numerous epidemics, nor to speak of more than a few of the various cities, whose sanitary history furnishes evidence of the close connection between the character of the drinking water and the mortality from typhoid fever.

The statistics show that cities drawing their water supply from adjacent rivers have high death rates from typhoid fever. Among these may be mentioned Allegheny (11.23), Denver (21.7), Washington (4.6), Jersey City (7.6), and Philadelphia (4.08). All these death rates are per 10,000 of population, and this will be the standard used throughout the rest of this paper.

Newark and Chicago, as will be mentioned later, have both instituted improvements in their water supply. Previously they drew their water supply from the Passaic and Lake Michigan, respectively, and each showed a high death rate from typhoid fever.

Let us now consider more in detail the cases of some of the larger American and European cities.

The city of the United States showing the lowest death rate from typhoid fever during the census year, was Brooklyn. This city is remarkably well sewered and had, until the last few years, a most abundant supply of pure water. This was drawn from driven wells, and the filtration through successive layers of gravel and soil was supposed to insure a very pure water. Lately the supply shows signs of giving out, and there are also evidences that the filtering process is not working as well as might be desired. Brooklyn's death rate from typhoid fever for some years has been about 1.5. This is very low and compares most favorably with those of the large European cities where typhoid fever is now almost extinct.

New York has an abundant supply of good water, but is not well sewered. Its death rate from typhoid fever ranges at about 3. In its case we must take into account the relatively and absolutely large number of the floating and transient population. A considerable number of the cases of typhoid fever are undoubtedly contracted elsewhere, at health resorts, etc., and are brought to the city where they develop later.

In Boston, the sanitary condition of affairs is also good, the city being well sewered and having a good water supply. The death rate is about 3.5. Baltimore has a fairly good water supply, but its death rate from typhoid fever (5) is relatively high. As stated by Osler in his report on typhoid fever in Baltimore, it has practically only surface drainage. The excreta are received into privy pits, of which there are about 75,000 in the city. There must be leakage in a large number of cases with subsequent saturation of the ground about, and contamination of the rain water passing through such ground. This however, cannot be said to entirely account for the high death rate. There are a certain number of wells in the city from which dairies draw their water, and contamination of the well water from the polluted soil undoubtedly takes place. But the question of personal and domestic uncleanliness and lack of proper prophylaxis is an important factor. Previous to the introduction of the present fairly good water supply the death rate from typhoid fever was one-third more than it is at present.

Philadelphia gets its water from the Schuylkill river. The sewerage of the city is fairly good, so that the relatively high death rate from typhoid fever (3.24 to 4.08) may safely be ascribed to lack of purity in the water supply. The water is not filtered, as the authorities hoped that by allowing it to stand above a large dam, it would be purified by sedimentation.

Washington shows the highest death rate from typhoid fever of all the larger eastern cities (6.7). This is due chiefly to two causes. Though Washington has a fairly good water supply, drawn from the Potomac river some miles above the city, there are scattered throughout the city over two hundred wells, the water from which is used by the people around. The poorer classes prefer this to Potomac water. There are also a large number of box privies, such as was spoken of in the case of Baltimore; over 14,000 within the city limits. Finally the outlet of some of the sewers in the low lying parts of the city are below tide-water level, and the excreta, etc., are washed back and escape into the ground, soaking it and so contaminating the water of the various wells. So that we have almost an ideal condition of things to bring about a high mortality from typhoid fever. The only wonder is that it is not higher. In the admirable report of typhoid fever in the District of Columbia by a committee of the Medical Society of the District, all these points are brought out most clearly.

Chicago furnishes a good example of the close connection between polluted drinking water and typhoid fever. Previous to 1882 this city drew its drinking water from Lake Michigan. The intakes or cribs of the water system were close inshore and the water taken in was polluted by sewage from the Chicago river, which receives the sewage from the greater part of the city, and the Lake Shore conduits. The water was often so polluted as to be absolutely undrinkable, and so may even be said to have been less dangerous on that account. Whenever there was a heavy rainfall the sewage was washed down into the river and far out into the lake, and as a consequence the mortality from typhoid promptly rose. In June, 1892, there was a rainfall of 16.58 inches, and the number of deaths from typhoid fever leaped from 55 in June to 211 in July. Chicago is still supplied with water from Lake Michigan, but it is brought from far out in the lake by means of four four-mile tunnels. The two chief ones were completed in 1892. In 1892 there were 1,489 deaths from typhoid fever. In nine months of 1893 there were only 503 deaths, a reduction of over 60%. From January 1st, 1890, to De-

cember, 1892, the annual death rate was 11.5. In 1894 the death rate had fallen to 3.1, clearly showing the beneficial effects of purer water. Until 1892 Chicago had the highest annual death rate from typhoid fever of the seventeen principal cities of the United States. It is now only tenth.

An interesting instance of the effect of the purification of the water supply is shown in the cases of Jersey City and Newark, N. J. These two cities are practically under the same climatic and geographical conditions, being separated by the Jersey Meadows. Previous to April 15, 1893, both Jersey City and Newark took their water from the Passaic river, into which goes a great quantity of sewage. Up to that time the annual death rates from typhoid fever were as follows:

	1890.	1891.	1892.
Jersey City	9.1	9.5	5.3
Newark	6.0	8.1	4.5

In April, 1893, Newark began using Pequannock water from a water-shed unexposed to pollution, while Jersey City continued the use of Passaic water. A diminution in the death rate from typhoid fever to one-fifth of its former proportions took place in Newark, as shown below:

	1893.	1894.
Jersey City	6.0	7.6
Newark	2.8	1.5

The effect of filtration of the water supply upon the death rate from typhoid fever is well shown in the following table from the *Engineering Record* of October 27, 1894. It relates to the city of Lawrence, Mass., where typhoid fever is very prevalent. The filter was started in 1893, and by 1894 the death rate had fallen almost one-half:

	1890.	1891.	1892.	1893.	1894.
Population	44,654	45,911	47,204	48,355	49,900
Typhoid cases	193	207	172	141	101
Typhoid deaths	55	53	45	34	25
Death rate per 10,000	12.3	11.5	10.2	7.0	5.0

An abundant water supply alone, does not diminish the death rate from typhoid fever. This is shown in the case of Dantzic, a very badly sewered city, which in 1869 had an annual death rate from typhoid fever of 10. An abundant supply of pure water was introduced, but no marked reduction in the death rate occurred until the city was sewered in 1872, when it fell to 1.5.

New York has less than one-half the amount of water supply per capita than Washington and yet its death rate from typhoid fever is just one-half that of the latter city.

The experiences of other foreign cities furnish statistics going to prove the close relation of pure drinking water to the health of the community.

From 1841 to 1850, the decennium previous to the adoption of sand filtration for the purification of the Thames, Lea and New Rivers waters, the average annual death rate from typhoid fever in London, was 9.8. During the next ten years, which embraced eight to nine years use of the now well-known London filter beds, the death rate from typhoid fever was 8.7. That is, for the first decade during which the filters were in use the reduction of the mortality was about 14 per cent. For the decade 1871–1880, it dropped to 2.4, for that from 1881–1890, to 1.9, and for the past five years it has fallen as low as 1.4. This is a reduction in the death rate from typhoid fever alone of 86 per cent. since the introduction of the London filters.

In Munich, Vienna and Berlin, the death rates from typhoid fever are very low. The following table shows the death rate in these cities as compared to those in three American cities:

	1890.	1891.	1892.	1893.
Munich	.8	.7	.3	1.5
Berlin	.9	.1	.8	.9
Vienna	.9	.6	.8	.7
Chicago	9.2	15.4	10.6	4.5
Pittsburgh	....	10.	10.	11.1
Louisville	8.8	8.1	8.1	8.4

The fact that the population in these cities are great beer drinkers may, perhaps, have some influence in bringing about the low death rates from typhoid fever, but the main factor is the pure water supply. Vienna at present gets its water from the Schneeburg, through an aqueduct fifty miles long. Up to 1874 well water was used almost exclusively. Owing to defective drainage this was very impure and the annual death rate from typhoid fever was very high — 10 to 34.

Berlin gets its water from the river Spree and Lake Tegel, the waters of both being passed through sand filters.

Munich from 1854 to 1859, had a death rate from typhoid fever of 24. In 1860 the sides and bottoms of the privy pits were cemented and the death rate fell to 16.80. Between that time and 1864, good sewerage was introduced and the rate fell to 1.75.

In Stockholm before sewers were introduced the death rate from typhoid fever was 5.1. As the number of metres of sewer pipes increased, the death rate from typhoid fever steadily diminished, until in 1887, with 65,709 metres of sewers, the death rate was only 1.7.

Breslau, before being sewered, had a death rate from typhoid fever of 15.2. Ten years later, after proper sewers had been introduced, the death rate had fallen to 5.5.

But examples of this kind could be multiplied indefinitely. It is not evidence or statistics that are needed, for we have enough of both. What is now to be done is to bring this evidence home to those in authority and to induce them to institute the necessary reforms. There is no reason why any American city should have a higher mortality from this disease than the larger foreign cities, and as Osler says in his Report on Typhoid Fever, "Perhaps the best gauge of the sanitary condition of a city is to be found in the mortality returns from typhoid fever."

32 East Thirty-first Street.

IV. DANGERS OF THE DOMESTIC USE, OTHER THAN DRINKING, OF CONTAMINATED WATER,

WITH SPECIAL REFERENCE TO MILK AND OYSTERS AS CARRIERS OF BACTERIA.

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Water containing pathogenic bacteria may cause disease in many ways other than by being used for drinking purposes, these depend-

ing, for the most part, on an intermediate contamination of some article of food which is eaten uncooked.

Of the articles of food which carry the bacteria from contaminated water, those which are themselves good media for the growth of most bacteria, as, for example, milk, are by far the most dangerous, for simply washing milk pails with water containing the bacilli of typhoid fever may introduce the germs into the milk in which they can rapidly increase. Such seemed to be the mode of contamination of the milk in the recent very severe epidemic of typhoid fever at Stamford,[1] Connecticut.

There are other articles of food which will carry the living bacteria, but will not furnish a favorable soil for their multiplication such as oysters and ice cream. Butter, clams, salads and fruits may probably act as the carriers of pathogenic bacteria, but concerning their efficiency in this capacity we have as yet little definite knowledge.

MILK.— Milk, providing as it does, a favorable medium for the growth of most bacteria, has probably conveyed more disease from contaminated water than any other article of food. Cholera, diphtheria and typhoid fever have all been transmitted in this way.

The usual explanation of this conveyance of bacteria is that the pails were washed in the contaminated water, and in one epidemic at least, already quoted, that appeared to be the real explanation. In other cases the water gets into the milk during cooling, while in still others the water is used to increase the bulk of the milk.

Cholera.— The conveyance of the bacillus of cholera from contaminated water was well demonstrated in an epidemic on shipboard reported by Simpson.[2] Of the ten sailors who drank the contaminated milk all had cholera, while of the remaining fourteen members of the crew only one had cholera. The milk was furnished by a man who washed the clothing of the crew. He admitted having mixed the milk with a fourth part water from a tank, the water of which had caused an epidemic of cholera in the neighborhood.

Diphtheria.— Out of eleven epidemics of diphtheria which I have collected[3] and which were caused by milk, in two, Henden[4] and Cardiff,[5] the milk was supposed to have been contaminated by the well water used at the farms, which was found to contain sewage. At Cardiff the epidemic was stopped by closing the well.

Typhoid Fever.— Typhoid fever has been shown to have been transmitted by milk in many epidemics and in some of these contaminated water has been the source of the trouble. Of fifty-three

epidemics of typhoid fever due to milk[6] in nine the contamination originated from foul water.

An epidemic of typhoid fever, due to the contamination of milk by the contaminated water of a stream, occurred in Geneva, Switzerland, in 1890.[7] A number of cases of typhoid fever occurred among the consumers of one milk supply. No case of typhoid fever was found in the family of the milkman or dairyman. The dairyman, however, washed his pails in a stream in which a neighbor was washing the clothes of a typhoid fever patient. So strong was the evidence against this dairyman that the milkman sued him for damages and recovered fifteen hundred francs.

A still more interesting epidemic of typhoid fever illustrating the way contaminated water may enter milk during cooling occurred in Springfield, Mass., in 1892.[8] In this town of forty-seven thousand inhabitants there were one hundred and fifty cases with twenty-five deaths: one hundred and one had milk from the same dairy and one hundred and thirty-five may have had some of the milk. This milkman received his milk from several farms, and on that account there was considerable delay in ascertaining the source of the contamination, for the milkman did not encourage investigation at the farm on which the contamination took place. Here the farmer's daughter was found to be suffering from typhoid fever. The privy contents were emptied on a field through which the laborer's walked. The milk cans were cooled by submerging them in a well after first plugging them with wooden stoppers. The morning's milk remained submerged in this well all day. The well was covered with planks on which were masses of manure. The plugs in four out of nine cans examined were found to leak. On bacteriological examination this water was found to contain colon bacilli, thus giving evidence of fecal contamination. Other epidemics where milk has apparently served as the carrier of the bacillus typhosis from contaminated water are those at Warwickshire in 1883,[9] Gronigen in 1885,[10] Shoreham in 1886,[11] Minnegue in 1887,[12] Leeds in 1892,[13] Brixton in 1894[14] and South Lambeth in 1894.[15]

OYSTERS.—Besides milk the other article of food which has been demonstrated to be an important conveyer of pathogenic bacteria from contaminated water to the human body is the oyster. This property is probably shared by other shell fish although it is only in the case of the oyster that the facts have been thoroughly demonstrated.

Typhoid Fever.—To Dr. W. H. Conn, of the Wesleyan University,

belongs the credit of having established this fact, and with the publication of his article[16] in December, 1894, practically begins the literature on this subject. In the autumn of 1894 an epidemic of typhoid fever broke out among the students at Wesleyan University. Twenty-six cases appeared between October 20 and November 9. Of these twenty-three were pronounced, thirteen were very serious and there were four deaths. After a long series of investigations and the exclusion, one after another, of suspected causes of the epidemic the following facts were conspicuous : all those attacked were men, all students of Wesleyan University, and all but three were members of three out of seven college fraternities. Of these three college fraternities twenty-five per cent. of the members were attacked. With these data he searched for some common cause of infection one or two weeks previous to the outbreak of the epidemic. He found that on October 12, eight days before the occurrence of the first case, all the fraternities had their annual initiation, followed by a supper. All the articles of food used at these suppers had come from different sources with the single exception of the oysters, all the three fraternities affected being supplied by one dealer, while none of the other four ate these oysters. The oysters were eaten raw. It was found that two of the three cases occurring in men not members of these fraternities had eaten oysters from the same supply. Of twenty alumni who attended these suppers, two suffered from typhoid fever, and of five Yale students who attended two were taken with typhoid fever four weeks later. Having ascertained that the oysters were the carriers of the infection, he turned his attention to ascertaining the cause of the contamination of the oysters. He found that the oysters were grown in Long Island sound and were freshened in a creek about 300 feet from the outlet of a private sewer from a house where there were two cases of typhoid fever. Conn thus demonstrated that the disease, with one possible exception, occurred only in consumers of these oysters, that these oysters were the only common article of food, and that the oysters were fattened in a place where they were liable to contamination by sewage from typhoid patients. It remained to be demonstrated that typhoid bacilli could find a habitat in the oyster and could live there long enough to be active at the time the oyster was used as food. It had already been shown by de Freytag[17] that the Bacillus typhosis could live in a concentrated salt solution for five months, and by de Giaxa[18] that it could live in unsterilized sea water nine days and in sterilized sea water

twenty-five days. Foote,[19] of New Haven, by a series of laboratory experiments, ascertained the following facts :

1. The Bacillus typhosis will live at least eight days in water taken from an oyster bed.

2. Oyster juice contains a varying number of bacteria, but fewer than occur in the water in which the oysters live.

3. The Bacillus typhosis injected into oysters will remain abundant for two weeks, after which period the number present is diminished, but they can be found thirty days after injection. The Bacillus typhosis will live longer in oyster juice than in water. It has more recently been shown by Herdman and Boyce[20] that oysters can live for a prolonged period in water rendered opaque by sewage. They can to a certain point render clear water containing sewage. They find an enormous increase in the bacterial contents of oysters brought from the sea and freshened near a drain pipe, the number increasing from 10 to 17,000 in one case. They also find that the Bacillus typhosis will live in oysters fourteen days.

Enteritis and Typhoid Fever.—Soon after the publication of Conn's paper reports of suspicious cases of oyster typhoid and enteritis were frequent. Sir William Broadbent[21] related six separate cases he had seen in consultation in which he attributed the typhoid fever to the eating of raw oysters.

Dr. Johnson-Lavis[22] called attention to the large number of cases of gastro-enteritis following the eating in Naples of oysters which had been freshened in the foul waters of Santa Lucia. Grant[23] wrote of four men who ate oysters together on the evening of Nov. 5th, of whom, on the 23d, three were sick with typhoid fever. Dr. W. Wilson[24] of Florence, Italy, reports several cases in which the evidence against the oysters is strong.

An interesting case is reported by Fitzgibbon[25] in which an infection with typhoid fever is attributed to oysters. These oysters were brought direct from the sea and were not fattened. They had, however, been stored in a house where there was a case of typhoid fever. Blyth[26] writes of a dinner party of six people, all of whom ate raw oysters ; all were attacked with severe diarrhœa and other symptoms of gastro-enteritis and one subsequently developed typhoid fever.

An outbreak of disease following the ingestion of raw oysters occurred, as reported by Chantemesse,[27] at l'Herault, France, last February. This town had been free from typhoid fever for about a year. On February 15th a basket of oysters from Cette was sold

and eaten raw by fourteen persons, all of whom were afterward ill, eight with slight diarrhœa, vomiting and malaise, four with putrid dysenteric stool and two with severe typhoid. Others in the same houses who ate no oysters remained well.

Perhaps the most important recent paper on this subject is that of Arthur Newsholme,[28] the Medical Officer of Brighton, England. Of 181 cases of typhoid fever occurring at Brighton during the years 1893–1896, inclusive, 56, or about 31%, were attributed to shell fish, and of these 36 were attributed to oysters and 20 to other shell fish. Nearly all these shell fish were traced to one source, and at this place the oysters lay between high and low tide in mud which showed evidence of sewage. Sewers discharging near the beds of both the oysters and mussels contained the sewage of several thousand persons.

Cholera.—That oysters may have played some part in the extension of the epidemic of cholera in England in 1893 is suggested by the report of the Medical Officer of the Local Government Board.[29] The evidence, however, is circumstantial and not convincing. Grimsby and Cleethropes, two watering places at the mouth of the Humber, are at the apex of a triangle which includes 34 of the 50 places attacked. Two hundred and thirty-five thousand excursionists visited these places during the two months that cholera prevailed. These places distributed 400,000 oysters a week. The oyster beds are periodically bathed in sewage.

On the other hand, it has been found by Frankland [30] that cholera bacilli if introduced into oysters usually disappear in six hours. In two cases they were present in 24 hours. In no case in 48 hours.

The recent publication of the Local Government Board of England on oyster culture in relation to disease [31] shows by a series of excellent maps the danger of many of the oyster beds of the English coast from sewer contamination.

CONCLUSION.

1. Most articles of food which are eaten raw and are liable to be washed with contaminated water may be carriers of pathogenic bacteria.

2. Milk, being a good culture medium for most bacteria, is a most dangerous article of food when taken raw if it has been contaminated by foul water, as proved by many epidemics.

3. Oysters are very liable to contamination if freshened near the opening of sewers. Oysters which have become contaminated have,

when eaten raw, caused gastro-enteritis in some cases and in others typhoid fever. The Bacillus typhosis is visible in oysters from 14 to 30 days, while the Bacillus choleræ will live usually but a few hours.

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V. WATER PURIFICATION.*

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The necessity for the purification of the water supplied to nearly all of our large American cities need not be dwelt upon at length. Typhoid fever and Asiatic cholera are now known to be transmitted chiefly by means of drinking water. What influence the Proteus vulgaris and allied species of bacteria, so commonly found in water,

* The great magnitude of the subject at the present time must be accepted as the writer's excuse for the brief mention of methods considered and the entire absence of many unimportant methods. Bacterial purification alone has been considered, for by this means we can gauge results of the various methods more accurately.

may have upon the production of cholera morbus is not definitely known, but it is probable that the influence is a strong one.

When we consider the immense annual destruction from typhoid fever in almost all our cities, the necessity for purification of contaminated supplies is evident.

The following table, compiled by Mr. John W. Hill, shows very clearly the influence of proper methods of water purification upon the death rate from typhoid fever :

CITY.	Typhoid mortality, 1890 to 1894 per 100,000.	Water supply.
The Hague	4.9	Filtered from sand dunes.
Rotterdam	5.2	Filtered from river Maas.
Christiania	6.8	
Dresden	6.9	Filter gallery, River Elbe.
Vienna	7.	Springs in the Schneeburg.
Munich	7.1	Springs, Mangfall valley.
Copenhagen	7.9	
Berlin	8.	Filtered, Lake Tegel and River Spree.
Breslau	11.6	Filtered from River Oder.
Amsterdam	13.9	Filtered from Haarlaem Dunes.
Stockholm	14.3	
Brisbane	14.3	
London	14.6	Kent wells, filtered from Thames and Lea.
Edinburgh	15.8	Filtered from reservoir in Pentland hills.
Trieste	17.	
Brooklyn	19.	Impounded and wells.
New York	20.4	Impounded from Groton and Bronx rivers.
Davenport, Ia.	21.4 (1895–26)	Mechanical filtration from Mississippi.
New Orleans	21.4	Rain water from tanks and cisterns.
Sydney	21.6	Impounded from Upper Nepeau.
Hamburg	21.8 (1895–6)	River Elbe (filtered since May, 1893.)
Budapest	22.4	Ground water from wells.
Glasgow	22.8	Lake Katrine.
Brussels	26.2	
Paris	26.4	Rivers Seine, Marne, Vanne and Ourcq canal, wells, etc.
Manchester	27.6	Lake Thirlmere.
Venice	30.2	
Milwaukee	32.	Lake Michigan.
Rome	32.2	Fontanadi Trevi, Acqua Felice and Paoli.
Boston	32.6	Lake Cochituate and Sudbury river.
Detroit	33.8	Detroit river.
Dayton	36.	Diven wells.
Turin	36 8	
Liverpool	37.	Lake Vyrnwy.
Buffalo	39.2	Niagara river.

CITY.	Typhoid mortality, 1890 to 1894 per 100,000.	Water supply.
Providence	39.2	Pawtuxet river.
Covington	39.4	Ohio river.
San Francisco.....	40.2	
Prague	43.2	
Minneapolis	45.4	Mississippi river.
Baltimore	45.8	Lake Roland and Gunpowder river.
Newark	45.8	Impounded from Pequannock river since April, 1892.
St. Louis	47.	Mississippi river.
Newport, Ky......	47.5	Ohio river.
Philadelphia	48.2	Delaware and Schuylkill rivers.
Denver	48.3	South Platte river.
Cleveland	49.2	Lake Erie.
St. Petersburgh ...	52.3	Filtered from River Neva.
Cincinnati	52.4	Ohio river.
Moscow	57.	Springs, ponds, Moscov and Yanzi rivers.
Toronto	57.8	Lake Ontario.
Quincey, Ill.......	58.	Mechanical filtration from the Mississippi river.
Dublin	58.8	Filtered from river Vartry.
Knoxville.........	61.9 (1895—59)	Mechanical filtration from Tennessee river.
Milan	62.	
Jersey City	75.	Passaic river.
Washington	76.6	Potomac river.
Louisville.........	79.4	Ohio river.
Chattanooga	80. (1895—48)	Tennessee river.
Chicago	84.	Lake Michigan.
Pittsburg	91.7	Allegheny river.
Lowell	92.4	Driven wells and Merrimac river.
Atlanta...........	92.8 (1895—43)	Mechanical filtration from Chatahootchee river.
Lawrence.........	96.2 (1895—48)	Natural filtration from Merrimac river since 1893.
Alexandria........	162.4	Nile.
Cairo	189.4	Nile.

The above table offers much for careful consideration. It will be noticed that among the first on the list we find principally European cities using natural methods of filtration. Lower down in the list, and with an increasing mortality, we find the American cities, either without any method of purification or methods inadequate to materially lower the death rate. Davenport, Quincy, Knoxville, Atlanta and Chattanooga possess filtering plants, but it is evident that efficiency is not so great as in the European filters. A few apparent discrepancies exist in the table. Hamburg is stated to

have had a mortality of 21.8. In 1893 a filter plant was installed resulting in a reduction of the rate in the following year to 6 per 100,000. St. Petersburgh's high rate is ascribed to the difficulties attending filtration of Neva water. The amount of suspended material is so slight that the formation of a film on surface of filter is not possible (?). Lawrence started a filter in 1893, resulting in a diminution of the typhoid death rate from 96.2 to 48, and it was easily proven that all the cases occurring were due to drinking unfiltered water obtained from a polluted canal.

All methods of water purification may be conveniently discussed under two separate headings, natural and artificial. The natural processes usually considered as tending to render a return of a polluted water to its original condition are as follows: nitrification, percolation, oxidation, sedimentation, sunlight, heat and cold.

Nitrification is dependent upon the action of micro-organisms that carry on their specific function upon ammonia resulting from destruction of organic matter contained in water or soil. The first step in this destruction of organic matter is due to organisms of putrefaction forming ammonia as the important product. Following this action, the so called nitrous organisms change the ammonia to nitrous acid, and in the final step nitric organisms change the nitrous acid to nitric acid. Essential conditions for this change to occur, are presence of oxygen, suspended material in the water for the zooglœæ of these organisms to attach themselves to, and the presence of saline constituents for the fixation of the acids as formed. The activity of this process in water is not great, due to inimical conditions, the most important of which is sunlight. All development and functional activity of these organisms cease in bright sunlight.

Percolation of water through the superficial layers of the soil is Nature's method, *par excellence*, for the purification of water. Under conditions existing in the soil, we have those most favorable for the process of nitrification. Percolation through a sufficient layer and properly adapted soil will absolutely sterilize a polluted water, this action depending on filtration, whereby suspended materials including bacteria are intercepted in their passage, and upon nitrification, the result of which is to so reduce organic pabulum that pathogenic and other organisms rapidly disappear from lack of nourishment and other unfavorable conditions for growth.

Oxidation of organic matter in water due to the direct action of atmospheric oxygen is decidedly slight, if at all. Prof. Leeds'

analysis of Niagara river water, before and after passing the Niagara Falls, showed only very slight differences. Prof. Mason performed very interesting experiments, in which he attached bottles containing mixtures of sewage and water to the connecting rod of a horizontal engine, allowing agitation to continue for varying lengths of time up to sixteen hours. Analysis before and after demonstrated only the slightest change. Bacterial reduction in water violently agitated with air is probably very slight. Pohl (1884) claimed a reduction in micro-organisms from 4147 to 728 per c.c. after violent agitation by hand for one hour. Numerous investigations since that time have given contrary results. In this connection, the length of flow necessary to purify a stream may be considered. Newburyport, Mass., had a shortage in its regular supply in Jan., 1893, and pumped directly from the Merrimac river, even after timely warning of its pollution from the State Board of Health. The result was an epidemic of typhoid fever, raising the number of reported cases for that month from the usual 1, to 34. An epidemic was in progress at that time in Lowell, twenty-six miles above (Sedgwick, *Boston Med. and Surg. Jour.*, Mar. 16, 1893). Instances parallel to the above have so often occurred that the adage, "No river is long enough to purify itself" would seem to have been about proven.

Cold undoubtedly has a general inhibiting influence upon the growth of bacteria in water, but, notwithstanding this fact, the number of bacteria in any one water will be greater in the winter months, due to the great destructive action of the solar rays during the summer. The following tabulated statement of experiments performed by Prof. Prudden in 1887 shows how little the influence of cold can be relied upon to destroy pathogenic bacteria :

	Original water.	4d.	11d.	18d.	37d.	51d.	66d.	77d.	103d.
B. Prodigiosus.....	6300	3000	....	....	22	Sterile.	....	....	
Prot. Vulgaris.....	8300 Per c.c.	....	....	88	....	....	....	....	
Liquifying bac.....	800,000	Sterile.	....	....	....	....	....	....	
Staph. Pyog. Aureus..............	Uncountable	....	....	....	....	....	66000.	....	
Fluorescent bac...	....	......	....	....	....	....	....	85000.	
B. Typhi Abdom..	....	....	1,000,000	....	....	....	....	72000.	7000.

In the above experiments the organisms were subjected to a steady cold temperature of from 16° to 30° F. Much more marked was the influence of alternate freezing and thawing. With the typhoid

bacillus, alternate freezing and thawing of three times in three days proved destructive. It has been proven, both experimentally and statistically, that extremes of winter weather have so little effect upon the typhoid bacillus that no protection from this source can be assured users of a water containing them.

Heat was formerly thought to have some effect in reducing the number of bacteria in water exposed to warm summer sun. Investigations by Buchner and by Ward, using alum solutions between the sun's rays and the bacteria under investigation, proved that the destruction was due solely to light.

Sunlight plays a most important part in the destruction of water organisms. Pathogenic organisms also are very sensitive to light influences. Buchner's and Marshall Ward's experiments in this direction showed that typhoid organisms were destroyed absolutely by exposure to direct sunlight for two hours. Diffused daylight has the same effect, but only after several hours' action. Buchner, experimenting upon water from the river Isar, collected at different times during the day, found the number of organisms much reduced during the time the sun shone brightest. Further experiments conducted by the same observer, in the clear water of Lake Sterneberg, demonstrated the activivity of the sun's rays even to the depth of eight feet. Typhoid plates exposed for four and one-half hours at that depth resulted in the death of the organisms. The smaller number of bacteria found in exposed waters during the summer months is largely due to the destructive influence of the solar rays.

Sedimentation plays an important part in the purification of certain classes of water, notably those of quiet lakes. In running streams the effect of sedimentation is not very strong, and, although appreciable, is of no practical importance. Artificially, purification by sedimentation is often resorted to, and will be considered under artificial methods.

Artificial methods of water purification can be subdivided as follows: Natural methods,[1] including constant filtration, filter galleries, intermittent filtration and sedimentation. Mechanical methods, with and without coagulants. Distillation. Chemical methods, including direct addition of chemicals and those methods dependent upon the production of chemicals in the water by electrolytic methods. Domestic methods, including porcelain candle filters, natural stone filters, pressure through sand, charcoal, etc., gravity

1. So called, because approximating Nature's methods.

through sand, charcoal, etc., and by means of heat. Special methods for the removal of iron, algæ, etc.

Since 1839 filtration of water through beds of sand has been practiced in London, and while yielding a clear product, the efficiency of such filtration in preventing the passage of *materies morbi* was much questioned. It was not until Koch's method of plate cultivation was introduced that their real efficiency was proven and an impetus given to investigations favoring their improvement. At the present time a very large number of such filters are in existence, though confined almost entirely to Europe, where greatly polluted streams render it imperative that efficient methods of purification be practiced. Experimental data and mortality statistics innumerable are to be found, showing just what these filters can do, and to what extent they can be relied upon to prevent the spread of water-borne diseases.

In brief, such a filter consists of an inclosing reservoir, about twelve feet in depth, and in superficial area from one to two acres. The bottom of reservoir is traversed by suitable under-drains, on top of which is placed a layer of coarse gravel to the depth of six or eight inches, then a nine or ten-inch layer of fine gravel, then coarse sand to the depth of twelve to sixteen inches, and finally a layer of fine sand about three feet in depth. Much variation exists in the relative depths of the various filtering layers in filters at different places. In localities where the mean winter temperature for any length of time averages below the freezing point, it becomes necessary to cover the filters to prevent freezing. Water is flowed upon the bed to a depth of three or four feet, at which height it is kept constant. The rate of filtration is regulated by a valve at the effluent, and is continuous until the sand becomes so clogged that water will not pass in the stated or required quantity with the pressure or loss of head allowed. Then it becomes necessary to drain the filter and remove the upper layer of sand to the depth of perhaps half an inch, when the filter is again ready for use. When by repeated scrapings the fine sand layer becomes reduced to sixteen inches, fresh sand is added to the original height. Water containing much suspended material must stand a sufficient length of time in sedimentation basins to remove the grosser particles, otherwise the filter would become clogged too soon. It has been found more economical to sediment muddy waters before introduction to the filter, rather than to drain, and remove upper layer of fine sand too often.

It was formerly supposed that the superficial layer of sand stopped the progress of micro-organisms by the formation on the sand surface of a slimy coating. While this is true to a certain extent, there are other influences determining the effectiveness of such filtration. Examination of sand in Altona filters by Reinsch, demonstrated at least three per cent. of the original water organism below the slime layer. A progressive decrease in numbers was noted throughout the depth of sand. Various investigators claim that all organisms are stopped in their passage through the filter, and those found in the effluent are derived from the under-drains. Piefke (Berlin) concluded after careful investigation on the Berlin filters, that the process was purely a biological one, and that straining had nothing to do with it. In the experimental work at Lawrence (Prof. Sedgwick), using special organisms that were easily identified in the effluent, it was demonstrated that some did pass the filters under certain circumstances. Later researches at Lawrence show clearly that the organisms found in effluent are derived from both the under-drains and the original water. The question is not by any means thoroughly understood, but we may safely conclude that the process is a combination of physical and biological action.

The efficiency of natural filters depends upon many factors — thickness of sand layer, "effective size"[1] of sand grains, uniformity in size of sand grains,[2] rate of filtration, pressure on surface of sand due to loss of "head,"[3] the superficial area, and also the question of covering — all exert an influence. The best practice at the present time favors the regulation of filtration as follows:

Superficial area of bed..........	1 acre.
Rate of filtration..............	2½ million gallons per day.
Height of water in bed.........	3½ feet.
Effective size of sand grain.....	0.2 m.m.
Uniformity coefficient.........	2.0
Depth of coarse sand and gravel,	2½ feet.
Depth of fine sand.............	3 ft. Not allowed to become less than 16 in.

The Hamburg filters, completed within a few years, are modern in every respect and differ somewhat from the older ideas. The water is first allowed to remain in decantation basins, and after 16 to 20

1. Effective size, 10 per cent. by weight of particles are smaller and 60 per cent. larger than figure given.

2. Uniformity coefficient, rate of A to B when values of A and B are such that 60 per cent. by weight is finer than A and 10 per cent finer than B.

3. Head, difference between level of water in filter and level in effluent reservoir.

hours' sedimentation the upper two-thirds of water only is conducted to the filters, the remainder being emptied with the deposited material. The filters are open, have a superficial area of 7,650 square meters (1.88 acres) and contain a lower layer of coarse and fine gravel .6 meter in depth. On top of this is a fine sand layer to the depth of one meter. As occasion requires the upper layer of sand is removed and washed with filtered water. When, due to repeated scrapings, the upper fine sand layer becomes reduced to 40 centimeters (16 in.) new sand is added to the original height. The size of filter bed is not in conformity to the English custom. In England the beds are one acre in superficial area, they claiming for this size greater ease in handling, less liability to uneven filtration and cracking of filtering surface. Since the installation of filter plant at Hamburg, the death rate has very materially decreased, and from an average typhoid mortality of 21 per 100,000 for the years 1890 to 1894, inclusive, it had dropped to six in 1894.

The average results of filtration of Thames water for the partial supply of London for several years past has been a removal of about 98 per cent. of the contained bacteria. The typhoid mortality has been in accord, averaging about 15 per 100,000. This is a most remarkable result considering the immense population and the filthy water dealt with.

No more impressive illustration of the effectiveness of natural filtration can be given than the often quoted Hamburg cholera epidemic of 1892, and the comparative freedom of Altona from the disease. Both cities are in close proximity. In fact they merge one into the other and no boundary exists. Both empty their sewage into the Elbe and draw their water from the same stream, Hamburg taking it from a point above both cities and Altona below. During August, 1892, a band of Russian gypsies encamped on the banks of the Elbe and the excrement of one of its members, subsequently found suffering from cholera, was emptied into the river. There speedily followed an epidemic of the disease in Hamburg, with a total number of cases of 7,427, and 9,321 in August and September, respectively. During the epidemic there occurred 17,020 cases with 8,605 deaths. Hamburg delivered water to its inhabitants with practically no purification followed by the above disastrous results. Altona, although deriving its supply from the same river and immediately below both cities, after receiving the sewage of almost 800,000 people, escaped the epidemic with but comparatively few cases and these were largely imported. Needless to say Altona

filtered its water before delivery. Notwithstanding filtration, a small epidemic of cholera started in Altona during December, 1892 and January, 1893. Investigations by Prof. Koch proved this to be due to freezing of the Altona beds while removing the slime-layer, resulting in cracks more or less large and the passage of unfiltered water. In previous years, during the winter months, Altona suffered from typhoid epidemics following closely upon the same condition in Hamburg. This never occurred in the summer even though an epidemic was in progress in Hamburg or towns above. It was conclusively proven that this was due to freezing of the beds, and illustrates how important it is that proper coverings be applied to those places where freezing can occur.

Warsaw, Russia, filters its water from the Vistula, effecting a reduction of the contained bacteria from 1500 to 30 per c. c. During the cholera epidemic of 1893, the disease raged in all the surrounding villages on both banks of the river, while Warsaw escaped with but few cases. Typhus fever, formerly prevalent there, has occurred but rarely since filtration of the water has been practiced.

In Lawrence, Mass., the typhoid mortality has been over 100 per 100,000. During the year following the distribution of filtered water the mortality was reduced more than one-half and it was satisfactorily proven that the cases occurring were due to drinking unfiltered water.

The intermittent method of filtration as practiced at Lawrence differs from that previously described in that the water is applied to the filters intermittently, the water being allowed to pass the filters 16 hours and the filter draining the remainder of the 24. The principle involved is the admission of air to render the nitrifying organisms more active. Slightly better results are obtained at certain seasons, but practically it has not been proven that the method is superior to those where the water is allowed to pass constantly. The filter is 2½ acres in extent and designed to filter 5,000,000 gallons per 24 hours. The results during the first year of service were as follows:

	Bacteria per c. c.	Removed.
River	19900.	
Effluent at filter	264.	97.58%
Reservoir outlet	139.	98.73%
City hall tap (1½ miles from filter)	90.	99.17%
Laboratory tap (2½ miles from filter)	82.	99.25%

(Fuller, Jour. Am. Pub. Health Assoc.)

Later reports average more perfect results, showing a removal of 98.4% of the contained bacteria as tested in water at effluent. During the winter of 1893–94 a severe epidemic of typhoid fever occurred at Lowell, whose sewage empties into the Merrimac 9 miles above Lawrence. Contrary to experiences prior to filtration, Lawrence was not affected.

At Worms and Magdeburg a rather different method of filtration is practiced than those described. Sand is mixed with a double silicate of potassium and sodium and pressed into plates 1 meter square and 20 centimeters thick. In the center is a cavity 2 centimeters deep in which the filtered water collects. The plates are baked at a temperature of 150 C. It is claimed that filters so constructed are more economical, filter more rapidly and are as efficient as the ordinary sand filters. Restoration of free flow is accomplished by slowly forcing water from below upward. No efficiency tests are at hand, although filters of much the same construction are in use at St. Petersburg, and judging from the typhoid mortality of the city for some years past (52 per 100,000), great efficiency is not obtained.

Filter galleries, properly considered under natural methods, consist of galleries or trenches excavated on a river bank a greater or lesser depth below low-water mark and separated from the river by the natural bank to the extent of several feet. The looked-for object is the filtration of the water from the river through the intervening bank. Since the slope of the land and flow of surface water is always toward the river, great risks of pollution from this source as well as from cracks in the bank must be considered. Many communities obtain a pure water by this means, but it is largely a matter of chance — as many more obtain a water but little better than before its passage into the gallery.

Sedimentation has its value as a means of purification, but it cannot be relied upon alone. Along the banks of some of our western rivers sedimentation has been practiced for a long time, more perhaps, to remove mud than for any organic purification expected. That bacterial purification does take place cannot be questioned. The following table shows to what extent this may be possible:

New River Co. at Stoke Newington.	Bacteria per c. c.
Cutting, above reservoir	677.
After passing first reservoir	560.
After passing second reservoir	183.

West Middlesex Co. at Barnes.

Thames water at Hampton	1437.
After passing first reservoir	318.
After passing second reservoir	177.

(PROF. FRANKLAND).

As a means of water purification without subsequent filtration, sedimentation is not to be recommended.

Mechanical methods of filtration were originally introduced for the removal of large particles from water intended for use in paper-making or other industries where it was essential that a clear water be used without reference to bacterial removal. Recently, considerable attention has been given to the removal of bacteria by means of these filters because they could be operated and constructed cheaper than natural filters. The machinery is protected by patents and prices kept so high that it is questionable whether plants of this character could be installed any cheaper than natural beds. These processes differ from the natural methods in that the sand is contained in tanks of varying sizes and the water is passed through in very great quantities, even as high as 300,000,000 gallons per superficial acre per day. All manufacturers have two varieties, the so-called "gravity" and "pressure" filters, differing mainly in that the gravity filters are open wooden tanks, into which the water must be pumped, then after filtration, again pumped into the service pipes. The pressure filters are closed steel tanks, placed in the direct main service, the service pumps passing the water through the filters into the mains. The rate of filtration does not, as a rule, vary in the two systems. A very large number of filters of the character are manufactured, all under patent-rights, all depending upon the same principle, and differing only in the mechanical methods for washing the filtering medium and adding the alum or other coagulant when used. They are operated both with and without coagulants, depending upon the water and the degree of purity desired. At the present time, the term "mechanical" filtration is usually applied to those methods where a coagulant is used. Without entering into details, it may be stated that filters of this class operated without a coagulant are practically valueless for the removal of bacterial life from a water passing through them. The rate of filtration is so high that the organisms are forced through and but a trifling reduction can be obtained.

Descriptions of such filters may be obtained from circulars issued by the various manufacturers.

Very meagre and unsatisfactory data are at hand showing the efficiency of mechanical methods. Dr. J. J. McKenzie made an examination of St. Thomas water after passing through a New York filter with the following results:

	Bacteria per c. c.
Before filtration	45,000
After filtration	90.
Percentage removed	99.8

Dr. Chapin, averaging three examinations of Long Branch, N. J., water, after passing same filter as above, obtained the following results:

	Bacteria per c. c.		
	1	2	3
Unfiltered water	259	298	248
Filtered water	5	2	3
Average removal	98.76%		

In neither of the above tests are any data given concerning the time of taking sample, and they can hardly be considered a test of the filters' efficiency, except at the time of taking sample. A very superior result might be obtained at certain times and not at others.

Manufacturers of the Warren mechanical filters publish the following efficiency tests:

Bacterial analyses of Mahoning river water from Warren, O., before and after treatment by the Warren Mechanical filter:

	Bacteria per c. c.		
Time Collected.	River Water.	Filtered Water.	Per Cent. Removed.
10.15 A. M.	2,373.	....	.....
1.15 P. M.	938.	....	.....
4.30 P. M.	1,248.	....	.....
Average	1,520.		
10.00 A. M.	......	16.	98.94
11.00 A. M.	......	11.	99.27
12.00 M.	......	11.	99.27
1.00 P. M.	......	41.	97.30
2.00 P. M.	......	97.	93.61
(filter washed.)			
3.00 P. M.	......	28.	98.16
4.00 P. M.	......	11.	99.27
5.00 P. M.	......	10.	99.34
5.55 P. M.	......	9.	99.40

As the river water remains in the settling basin and settles two hours before passing the filter beds, the results of the analyses of filtered water are compared with the average of the three samples of river water.

The above report is not at all satisfactory, for the river-water examinations were apparently determined at a different time from those of the effluent, and no mention is made of the rate of filtration.

Exhaustive experiments have been made by the Louisville Water Co. on several varieties of filters; but, unfortunately, the experimental work has been conducted privately, and no report has yet been published.

By far the most important investigation at present in print is to be found in the "Appendix to the Seventeenth Annual Report to the State Board of Health of Rhode Island" (Edmund B. Weston). The experiments extended from March 27, 1893, to January 30, 1894. Three filters were used. No. 1 contained a filtering media of pea gravel three inches, coarse sand one inch, and fine sand eighteen inches. In this filter varying sands were used and operated as both a mechanical and natural filter. No. 2 contained the same filtering media as number 1, and was used throughout the experiments as a natural filter. Number 3 was a Morrison filter and contained a filtering media of coarse crushed quartz ten inches, and twenty-four inches of fine crushed quartz, of an effective size of .59 mm. and a uniformity coefficient of 1.5. In filters 1 and 2 the sand was cleansed either by scraping about one-half inch off the surface or by washing the material thoroughly. Number 3 was cleansed by revolving a mechanical rake imbedded in the sand while washing with a reverse current of water until the wash water passed clear.

During about seven months parallel experiments were conducted upon the three filters. At the end of this time the experiments were discontinued with the natural filters because of it "having been satisfactorily ascertained that the length of run was much less than the mechanical filter, the bed became clogged and the rate of flow in the natural beds was but 30,000,000 gallons per acre in twenty-four hours, while the mechanical filter was run at the rate of 128,000,000 gallons per acre in twenty-four hours. The efficiency of removal of bacteria was not as high, and the results variable, either as the result of cracks in the filter or from some unknown reason." (Gardner T. Swarts, M. D., *Jour. Amer. Pub. Health*

Assoc., 1895.) After October, 1893, all experiments were conducted upon the Morrison filter in order to determine the best method of running the apparatus with the object in view of installing a plant of this kind for the filtration of Providence water. It was found that the Morrison filter could be operated to deliver 128,000,000 gallons per acre per twenty-four hours, using one-half grain alum per gallon, applied in the beginning of run in a "free flow," *i. e.*, a pint of alum solution containing 911 grains of the coagulent, added rapidly, thus causing rapid formation of film on surface of filter. Conducted in this manner satisfactory results were obtained, causing a diminution of the contained bacteria to the extent of 98.6 per cent. This certainly shows a great degree of efficiency, but several points are open for criticism in the Providence experiments, and the results obtained cannot be considered conclusive for reasons given in the following paragraphs. In the comparative experiments performed prior to October none of the plates were allowed to reach a maximum count. As a rule, but two days were allowed for development, and this was supposed to be sufficient, since the results were to be comparative. The fallaciousness of this can be readily seen when we consider the effect of the usual coagulents upon water organisms. Either a very large proportion are killed or so affected, that development, when subsequently plated, is very much retarded. The effect is noticeable with alum, and even with metallic iron treatment a marked restraining influence is apparent. Anthrax inoculated water, shaken with a small quantity of iron, and subsequently plated on agar, may not show an anthrax colony for several days when grown at body temperature. When colonies become visible they grow very slowly, and each will be surrounded with a zone of iron oxide. The toxic effect of alum on water organisms has been demonstrated by Frankland and other observers. The effect varies with the temperature of water for equal quantities of alum. Therefore it is evident that no value can be attached to results computed after two days growth, as in the tests under consideration. If we are to accept the theory of a biological factor in filtration, we must assume that varying rates of filtration will have an effect upon the growth of organisms passing a filter. The lower the rate of filtration, the slower a passing organism will grow, and *vice versa*. The results obtained with the natural filters at Providence were poor and not in accord with results obtained at Lawrence or Berlin, where experiments were conducted covering long periods of time and

under many varying conditions. In fact, the results obtained were not in accord with those obtained with filters in actual practice. This was doubtless due to the high rates of filtration employed.

In the experiments upon the mechanical filter only end counts can be of value for reasons just cited. Taking all end growths of samples collected one hour after starting filter, the average removal was 95.2 per cent of contained bacteria. In those taken thirty minutes after starting filter an average removal of 95.5 per cent. was obtained. The tests upon which the removal of 98.6 per cent. was based were taken at times when the filter was working in a "normal" manner. These periods were sixteen days in October and November, during ten of which tests were made, and six days in January. This manifestly is too short a time to determine with any great degree of accuracy the actual efficiency of any filter. The removal of test organisms, which in this instance was the bacillus prodigiosus, continued over a considerable period, gave very good results. As a rule 100 per cent. of the added organisms were removed by the filter.

During the early part of January the efficiency of filter was very much reduced, due, perhaps, to the addition of bouillon cultures of test organisms. Just how far this could have been due to the above cause was not proven. The sand was found to be coated with a brown slime removable only upon boiling with caustic soda. It was recommended that a periodical treatment with this material be a feature of the large plant. It certainly seems evident that a very high content of bacteria will decrease the life of a filter and possibly necessitate caustic soda treatment oftener than once in six months, as recommended. It was satisfactorily demonstrated that great care must be exercised in the addition of alum and without the "free flow," about three hours were necessary to obtain a satisfactory effluent. This necessary care upon which the efficiency depends is certainly objectionable, considering the carelessness of the average water-works employee.

Very satisfactory comparisons of the work done by natural and mechanical methods cannot be made at present, because sufficient data regarding mechanical filtration is not obtainable. Prof. Leeds considers it impossible to give a "categorical answer stating that either method is preferable in all cases. The preference depends upon the conditions, and when properly carried out, both methods, according to the evidence so far on record, appear to yield equally good results." It is evident from statistics at hand, as given for cities[1] using me-

1. See table.

chanical filters, the typhoid death rate has not been reduced to the extent it has in cities using natural methods, as instanced by the many European cities obtaining supplies from streams with a much greater degree of pollution than anything we have to deal with in America. Therefore, we must, in the light of our present knowledge, consider the natural methods superior.

Purification by distillation has lately assumed some proportions. In many of our large cities plants have been erected for the commercial production of water purified by double distillation. Subsequent aeration removes, to a large extent, the flat, insipid taste found in such waters. All large ocean steamers are provided with distilling plants, rendering it unnecessary to carry large supplies of fresh water. A pure and bacteria-free water can be obtained by this means, but the expense precludes the possibility of its adaptation to municipal supplies.

Of the chemical methods of water purification, we may consider those purely chemical and those dependent upon the production of chemicals in the water by electrolysis.

Traube has recommended calcic hypochlorite for purification on a large scale. He found that the addition of 0.000426 of the salt to 100 c. c. of water resulted in the complete destruction of all contained bacteria within two hours. At the expiration of this time, the addition of 0.000209 calcic sulphite decomposed all the hypochlorite. The amount of harmless salts remaining after such treatment is smaller than usually found in potable waters.

For purification on a small scale, many substances have been recommended. Potassium permanganate has been highly extolled, but in sufficient quantities to destroy the bacteria present a decidedly unpleasant taste results. Monol (calcic permanganate) has been claimed to possess the property of "purifying swamp-water, or even water containing vegetable poisons, to such an extent that no harm can result from drinking" (Friedel). This means of purification is attracting much attention in France at present, and observers claim a sterile water after the addition of very minute quantities of the salt. Subsequent removal of remaining permanganate is accomplished by passing the water over manganese binoxide. Tincture of iodine has been used, and Meillere (*Lancet*, January 23, 1895) claims that the addition of four drops to the liter will positively destroy all pathogenic bacteria in a few minutes.

But little experimental work has been done to determine the

efficiency of electricity as applied to the purification of water. Thus far the results obtained have not been satisfactory; either the water acquires a bad taste, or bacterial purification is slight. Hermite and Webster's electrolytic process will successfully sterilize water, provided the contained chlorides are excessive. The decomposition, resulting in formation of free chlorine and easily decomposable chlorine compounds, give the water an extremely bad taste, and may produce nausea and vomiting in those using it. Materials might be added to combine with the chlorine, but the result would be a dilute saline solution, more or less unpalatable. Opperman deduced from experimental work the impracticability of existing electrical processes, but found that a secondary treatment, using aluminum electrodes, relieved the water of all objectionable features, and feels convinced that cholera or typhoid organisms would be destroyed. The Roeske system of water purification uses electricity as an aid in its work, and claims good results. The water is conducted into a well, where it meets a quantity of metallic iron resting on a perforated plate. One pole of a dynamo is connected with the tray upon which the iron rests. This mass of metallic iron is kept in constant agitation by means of a metallic rake, to which the other pole of the dynamo is connected. A strong current of air is constantly pumped through the well to assist in the process. The water is pumped from this well through pressure filter tanks, passing in its course through four feet of sand at a rate of one gallon per superficial square foot per minute. It then passes to the top of a stand pipe, where it is made to descend in a shower against a current of air forced upward through it. Solution and oxidation of the iron, resulting in flocculent ferric hydrate, together with the electrolysis of saline constituents, producing nascent chlorine, are effective purifiers. It is thus a combination of chemical and mechanical methods. Unfortunately no efficiency tests have been made. The Anderson process is similar to the above, minus the electrical treatment. This consists of the passing of water through large revolving drums containing scrap iron. It then passes through a series of settling or decantation basins, where most of the ferric hydrate is deposited before passing into filter beds much like those used in London. Miquel made a series of tests on water from one of these plants, and claimed a removal of 99.3 per cent. of the contained bacteria.

Domestic filtration as a rule is not efficacious. But few filters are of any value and these to be of use must be handled understandingly and with great care.

The Pasteur filter consists of an outer metallic cylinder and an inner tube of unglazed porcelain. This inner tube is ten inches long, one and one-eighth inches in diameter, and a thickness of wall of one-eighth inch. It is closed at one end and at the other provided with a nipple through which there is a small opening for the passage of filtered water. The water is passed into the outer shell and forced through the porcelain tube by the pressure existing in the mains. With a pressure of sixty pounds about three gallons per hour can be obtained. Operated without pressure only one and a half gallons per tube per twenty-four hours can be secured. All suspended impurities are retained upon the surface of the inner tube, which can be easily removed for cleansing. The relative value of many different filters has been determined by G. Simms Woodhead and G. E. Cartwright Wood (*British Medical Journal*, December 29, 1894). Water infected with yeast plants and staphylococcus pyogenes aureus was passed through the filters for four days. Enumeration of organisms in the filtered water was made daily. Similar experiments were performed with various pathogenic bacilli and it was determined that only two filters were able to prevent the passage of organisms during that time, viz., the Pasteur and the Porcelain d' Amiente. No matter how carefully handled nor how often cleansed, a time will come when the filter becomes clogged or the organisms develop in the pores and grow through. It is therefore necessary to sterilize periodically and treat in some way to restore the original freedom of flow. Heat can be used but, the risk of breaking the tube is great. A soaking for half an hour in a five per cent. calcic permanganate solution, followed by a soaking in a sodic sulphate solution, will accomplish perfect sterilization and return to free flow. A daily brushing of the tube and a weekly treatment as above outlined will guarantee a germ-free water, provided the tube is without flaws.

The Berkefeld filter is very similar to the Pasteur except that the inner tube is made of an infusorial earth. It is 26 c. m. long, 5 c. m. external diameter and 1 c. m. thickness of wall. The yield is much greater than the Pasteur, the tubes of closest texture passing 750 c.c. per minute under a pressure of three and a half atmospheres. It yields a sterile water for a shorter time than the Pasteur.

The Crique filter is constructed much like the Pasteur, but possesses a larger filtering tube, held in position against a rubber packing by a set-screw on top. Tests performed on this filter demonstrated its ability to prevent the passage of bacteria. (Special Report Buffalo Health Department, W. G. Bissell, M. D.)

The Crystal Fountain filter consists of a natural stone tube enclosed in a metal receptacle. Resting against the tube and held in this position by the water pressure, is a piece of stone against which the filtering tube may be revolved for cleansing. The efficiency of this filter is good, but natural stone may contain seams and fissures not visible on the surface; thus care must be exercised in selecting. Due to the thickness of stone tube, it is difficult to sterilize and procure return to original free flow. The manufacturers of this filter have recently introduced a clay filtering tube which seems to be remarkably efficient. Dr. Adolph Sehrmann, Bacteriologist to the Chicago Board of Health, says: "Another filter was tested in this laboratory from December 22, 1896, to January 21, 1897, and was found germ proof during this period." In this test I understand that the filtration of tap water for this period was continuous, and during the time no bacteria passed the tube.

The Ellis Charcoal filter is a type of many designed for attachment to faucet, containing in this particular filter granulated charcoal to the depth of one inch. Innumerable filters are constructed on this principle, varying only in the material supposed to remove impurities. Charcoal, various sands, granulated iron, spongy iron, polarite and many other materials are used. Filters of this character remove only large particles, and instead of decreasing the number of bacteria in the effluent, there are, as a rule, a larger number due to development in the filtering media. A test of the Ellis filter attached to tap gave the following results:

Unfiltered water, bacteria per c. c.	455.
Filtering 10 minutes	405.
Filtering 20 minutes	380.
Filtering 30 minutes	445.
Filtering 50 minutes	450.
Filtering 60 minutes	435.

(W. G. Bissell, M. D., Report to Buffalo Health Department.)

The Acme filter consists of a metal receptacle containing three series of filtering material, composed of asbestos and moulded carbon, through which the water is forced by pressure in the mains. No efficiency tests are at hand, but analogous filters have shown but little value.

In the Carter stone-ware filter the water first passes through a sponge and then through the filtering material proper, consisting of

charcoal and Rockaway sand. It operates by gravity, and, like all filters of this kind, possesses but little power to remove bacteria from water passing through it.

Heat is the most valuable and most generally applicable domestic method for the destruction of pathogenic organisms in water. A vigorous boiling for five minutes will effectually destroy all dangerous bacteria, but the method renders a water unpalatable. Fremont (*La Medecine Moderne, Feb.* 23, 1895,) states that heating to 80° C. for twenty minutes will destroy pathogenic organisms without deprivation of contained gases or precipitation of salts, and therefore without modification in taste.

Processes for the removal of special impurities are sometimes required. Iron can be removed by mechanical filtration with alum (Drown, *Eng. News, June* 4, 1896). Algæ and other vegetable growths often develop to such an extent, particularly in stored water, that methods of prevention become necessary. Spontaneous pollution of this character is well illustrated by difficulties met with in the water supply of Cheltenham, Eng. (Garrett, *Brit. Med. Jour., Jan.* 7, 1893.) The water supply of this town is derived from the River Chelt and stored in three reservoirs, two of which were open and the other closed. Following numerous complaints of bad taste and odor, investigation revealed immense growths of chara in the open reservoirs. It grew most luxuriantly during the summer, breaking up in the autumn, and rendering the water turbid and foul smelling. All attempts at destruction of the plant were unsuccessful, and Garrett finally advised the use of covered reservoirs only.

The following conclusions may be deduced from the preceding paper:

1. Purification of water should be municipal, not domestic, because domestic filtration cannot be relied upon.

2. Domestic purification can be best obtained by heating to 80° C. for twenty minutes.

3. All evidence available at the present time favors the superiority of "natural" filtration for purification on a large scale.

4. With few exceptions, all American cities furnish their inhabitants a water that is at least suspicious, and in most cases polluted.

5. A continued typhoid mortality of over 20 per 100,000 means a polluted water and a preventable sacrifice of human life.

357 PENNSYLVANIA STREET, BUFFALO, N. Y.

VI. METHODS OF PREVENTING THE POLLUTION OF WATER.

BY EDWARD K. DUNHAM, M. D.,

New York.

In order to obtain an abundant supply of water, we are, in practice, obliged to make a choice between two great natural sources of water. We may either draw our water from the pure ground water of an uninhabited, or but sparsely inhabited, region, or we may utilize the natural collections of surface water which form the streams or ponds of such a region.

In the former case, in order to prevent pollution of this naturally pure water, we must so arrange our mode of collecting and distributing the water as to exclude any risk of pollution at its source or while it is in transit to the consumer. In the latter case we must guard the natural surface waters from pollution. In both cases the problem of preventing pollution resolves itself chiefly into a study of the practicable means of excluding sewage from all parts of the system of water supply.

Where the soil containing the ground water is so pervious that the latter can be obtained in sufficient quantity at reasonable cost the problem is a simple one, and will be briefly considered presently. Preventing the pollution of surface waters is a more complex matter, and had best first engage our attention.

The streams of a region constitute an abundant source of water for the reason that they are the natural drains of the region. They receive the rain which falls upon the ground, partly in the form of surface water which speedily flows into them, partly in the form of ground water which reaches the stream only after percolating through the soil, in which it may remain for several months before it finally emerges to form open or subfluvial springs.

These two sources of the water of streams and ponds differ widely from each other with respect to the chances of their containing sewage. As we shall see in a moment, the passage of the water through the upper strata of the soil brings it under conditions which strongly tend to deprive it of putrescible organic matter and to free it from bacteria. And observation has shown that in many cases the ground water of a region is entirely sterile. But the surface water that makes its way into very many of the streams of the country is

open to great risk of contamination with sewage, and is, in fact, frequently made the vehicle for its disposal.

As civilization advances and the population becomes more concentrated into towns and cities, the demand for an abundant supply of water becomes greater and more urgent, and at the same time the risk of sewage pollution of the surface water becomes proportionately increased. The demand for some satisfactory means of disposing of sewage without permitting it to pollute the streams appears, therefore, to be an imperative one, and we must turn our studies in this direction.

The natural fate of the organic matters contained in sewage is to undergo putrefaction, during which they furnish food for a numerous variety of bacteria. This decomposition, with its associated multitude of putrefactive germs, is, in all probability, highly unfavorable to the continued existence of specific germs of disease, but at the same time gives rise to substances which are repulsive to the senses or injurious to health. We cannot prevent, though we may postpone, these putrefactive changes by any means short of the actual destruction of the organic matter capable of undergoing them. We must, therefore, consider whether we cannot permit and control their occurrence under conditions which shall bring about a speedy but innocuous natural termination of the process before the sewage can find its way, as it inevitably must, into the natural drains of the country — the streams.

This can be accomplished if we allow putrefaction to take place in such a way that the oxygen of the air has free access to the materials suffering decomposition. Under these circumstances two groups of bacteria have an opportunity to develop and to bring about chemical changes which result in the so-called mineralization of the organic matter from which they obtain their nourishment.

The first of these groups comprises the putrefactive bacteria, which split up the organic matter and form the noxious substances that we designate as the products of putrefaction. Those products are then seized upon by the members of the second group of bacteria, which includes the nitrifying species, and caused to combine with the free oxygen present, thus converting them into substances, which, in themselves harmless, are no longer favorable to the support of undesirable germ life. They are, however, of considerable nutritive value to plants of higher organization.

The superficial layers of a porous soil furnish the conditions

required for this process of mineralization, if the putrescible materials are not applied to it in such quantity as to exclude a sufficient supply of oxygen for the second group of bacteria to affect the changes incident to their free and natural growth. And this can be avoided if the fluids containing the organic matter are applied to the soil intermittently.

This process, though often so considered, is not a true filtration, but simply a means of promoting speedy mineralization of organic matter. Its *modus operandi* may be conceived about as follows: the fluid portions of the sewage make their way slowly through the interstices of the soil, but the organic matter adheres to the surfaces of the solid particles of the latter, and there is subjected, in thin layers, to the action of the bacteria, in the presence of oxygen. During this process any specific bacteria of disease suffer a lively competition with saprophytic species under conditions which are in themselves unfavorable to the continued existence of the parasitic forms, so that there is every reason to believe that they soon become innocuous or die out. In either event they would not appear in the ground water in a condition capable of occasioning disease. As the process advances the saprophytic bacteria also die out, and this is the probable explanation of the observed fact that ground water is so frequently nearly if not quite free from bacteria.

In seaboard localities considerations of economy may make it desirable to discharge the raw sewage into a large body of tide water, or into the sea, but since in those cases there is no question of polluting otherwise potable water, their consideration does not fall within the scope of the present discussion.

In the majority of cases true economy, which must take into account not only the cost of disposing of sewage, but also that of securing an abundant supply of good water, as well as that of failing to do so, will probably dictate the adoption of some means of sewage disposal based upon the processes of mineralization which have been outlined. In many cases this might be combined with some form of agriculture adequate to defray at least a part of the expense, the mineralized sewage being nutritious to the higher plants. But such farming is by no means an essential part of this method of sewage disposal, unless vegetation be desirable in maintaining the porosity of a given soil.

It would be out of the question to consider, in a short paper, the details respecting the character of the soil and the methods of ap-

plying the sewage to it, which would be appropriate under the exceedingly various conditions pertaining to different localities. The results of an enormous amount of systematic work looking to an elucidation of those details has been published in the reports of the Massachusetts State Board of Health, which deserve the careful study of all those interested in the subject.

The aim in every case should be to establish and maintain the process of mineralization so that the changes it can bring about in the sewage shall be completed before the latter has receded into the soil to a depth unfavorable for the continuation of the process. When this is not done there is a chance for the sewage to appear in the ground water, where the process is checked, and, eventually, to find its way into the streams without having undergone the purification demanded. The details of management best adapted to accomplish that purification are, in the main, dependent upon the character of the soil available for the purpose. The results of experiment indicate that a fine sand is the material most suitable for the destruction of large quantities of organic matter, and that if the sewage be properly applied the virtues of the sand in this respect will be retained indefinitely. But other soils than sand may be utilized if their capacity be carefully studied and the details of management regulated accordingly.

It frequently takes some time for the process of mineralization to become fully established, and it is, therefore, essential that, in every case, the efficiency of a plant for sewage disposal should be studied, both bacteriologically and chemically, not only when first started, but as a necessary part of its intelligent management.

The principles which have now been briefly stated apply, not only to the disposal of sewage from large communities, but also to that of sewage and other liquid waste from single country dwellings. They furnish a means of abolishing the too common cess-pool, in which putrefactive changes take place under conditions preventing the complete mineralization of organic matter. What is required in such cases is an area of ground sufficiently extensive to obviate its saturation by the quantity of sewage it must receive, and some system by which the sewage can be applied either upon, or a few inches below its surface, intermittently. The whole area of ground can be divided into two or more plots which shall in turn receive the sewage. Such an arrangement gives each plot a considerable time in which to dispose of the sewage it has received and to become fitted for another dose.

The whole system should be free from receptacles in which the liquids could accumulate for more than a few hours before reaching the soil. Simple systems of this sort, which have stood the test of extended trial, are described in a scries of short articles which appeared, not very long ago, in the *New York Evening Post*, and have been reprinted by that journal in small pamphlet form under the title, "Health in Country Houses — The Disposal of Sewage."

Sewage disposal or purification by the foregoing process of committing it to the superficial strata of the soil, appears to yield a product of so good a quality that it may be discharged from the underdrains of the soil or sand bed into the streams without risk to those employing their water for drinking purposes. Both chemically and bacteriologically it compares favorably with spring water, except that the nitrates are present in larger quantities. These are among the end products of the mineralization, and do not militate against the conclusion that the effluent containing them is not to be regarded as a polluting fluid. This harmless character can only be assigned to the effluent, however, when the method is intelligently conducted.

Turning our attention now to the cases in which the ground water is drawn upon as the sole supply of watcr, we can understand the conditions under which it may be regarded as pure. If the deeper strata in which it lies are open enough to allow the water to flow with sufficient freedom, it may be collected by means of pipes driven into the ground. No simpler or safer method of tapping this supply can be easily imagined.

Where such driven wells are insufficient, dug wells or galleries may be constructed in which the ground water will collect and can be stored until required for use. These should have water-tight covers, and their sides should be impervious from the top to a distance of several feet (5 to 8), below the surface of the ground. Below this level the sides should be porous to permit the cntrance of the water. The impervious portion may be constructed of brick, stone or earthenware pipes laid in ccment and reinforced, if necessary, by concrete, the space around which is filled with sand, covered by a little soil and sodded. The lower part of the shaft may be constructed of stones laid without cement or mortar.

The rim of the well should be a little above the level of the surrounding ground, and the cover be cemented to it. Arrangements for ventilating the air space above the water in the well should also be provided, but in such a manner that reflux of water into the well would be impossible.

The fact that the well has been constructed in the manner described does not in the least warrant a neglect to provide proper means for the disposal of sewage, which must always be regarded as the most radical and enlightened measure against the pollution of water. Cesspools should especially be avoided, for they are usually so deep and so defective that the sewage they receive can find its way into the ground water, where the natural processes of mineralization can not take place.

The writer has laid special stress on the process of mineralization for the disposal of sewage, because he regards it as the most conformable to nature, and likely to be the most efficient in practice. Methods by which the organic matter of sewage is reduced in quantity by chemical or electrical means appear to him less enlightened because they require much greater skill for their proper conduct, and the chances for pathogenic germs to escape destruction appear greater. They are open to the risk of sudden failure through accident, are likely to be expensive, and are apt to yield products that are offensive.

338 EAST 26TH STREET.

VII. LIFE HISTORY OF THE TYPHOID FEVER GERM OUTSIDE THE BODY.

BY F. C. CURTIS, M. D.,
Albany, N. Y.

The consensus of scientific opinion is that the typhoid bacillus is the specific cause of typhoid fever; that it is cast off from the body of one sick with the disease in the excreta; that, *under favoring conditions*, it retains its vitality for a long time outside the body. What these conditions are, practical sanitarians are much concerned to know. We do know that this germ retains life in all degrees of cold; that it multiplies in the presence of suitable pabulum and moisture, such as is furnished by milk, water and soil; that it is destroyed by heat, by certain germicides, by other micro-organisms, by unsuitable and insufficient pabulum, and probably by dessication.

It is in the *soil*, the *sewer*, privy pit, cesspool, the *well* or *stream*, and the *atmosphere* that we want to study the life of the typhoid germ. And our conclusions must largely be drawn from clinical observation.

First, as to their life in the *soil*, the chief receptacle of typhoid excreta, in the country. It is well known that these germs live long

in this environment, and that hot, dry summers are followed by increase of the disease, which is attributed to a causal relationship with varying levels of ground water. Buhl and Pettinkofer place this interpretation upon this observation, viz.: that low ground water permits the air to penetrate the soil, and that thereby the germs are conveyed to and pervade the atmosphere; Liebermeister explains it by saying that the water, becoming low in springs and wells, the poison is thereby more concentrated. Neither explanation is in accord with the probable habit of this particulate germ.

To illustrate my own proposition as to the history of the germ in the soil and its method of reaching the subject, I will briefly state an observed outbreak, which is a type of many constantly occurring in the country. In a rural hamlet, remote from lines of travel, in which, for many years past, there has seldom been an autumn without two or three cases of typhoid fever, there suddenly develops an extensive epidemic of it — thirty cases in twenty-three dwellings, with five deaths. There has been a long period of dry weather, and the outbreak is preceded by sharp rain-falls. Mapping the little hamlet, strung for half a mile along the highway, and marking each house where the disease comes, in the date and order of its occurrence, we find successive cases coming in no geographical order, but simultaneously at remote points, indiscriminately. We find each has its separate water supply, and there is no common sewer, of course. What caused this fulminant outbreak thus affecting all parts of this village at once? There is no reasonable interpretation of the observations but this: for years past the soil has been sown with typhoid fever germs — these have remained vital for one year, possibly for a number of years — under the favoring conditions of unusually low level of ground water with oxygen supply and whatever comes with it, they have quickened and, perhaps, multiplied — following this came the rain-falls, and they were carried in the soil channels to all the sources of water supply over the entire area simultaneously, and all the people were simultaneously exposed.

My proposition then is: in the soil the typhoid germ has an environment where it may *remain* for an *indefinite length* of time vital; that, as universally agreed, it secures more active life or multiplication when the water is low in the soil; that it is then conveyed to all wells and streams to which its habitat is tributary, and in this way, and in no other, causes increased prevalence of the disease. There is no such thing as aerial infection, and the interpretation which im-

plies a concentration of poison in a low well is out of accord with the principle of a particulate germ. How long these bacilli will live in a favoring soil I do not think we can say or place a limit upon.

What is the fate of the typhoid germ in the *sewer*, its chief receptacle in the city? The moisture, absence of light, and abundance of dead organic matter there all favor its vitality. But it is met there by a vast quantity of inimical bacteria, which thrive well in sewage, and a *fundamental fact in the life-history of this germ is that it is destroyed by other bacteria.* In competition with these it dies speedily. In the drains from the Eastern Hospital at Homerton (reported in *Lancet*) typhoid bacilli were found, but none were found in samples taken a quarter of a mile away. Their complete extinction in the sewer is a matter of a few days at most; they begin a perilous journey when they enter it, and their only salvation is in a speedy transit to a more salubrious environment.

In the cesspool there is no reason why their life should be differently affected.

In the privy pit conditions are somewhat different, and many local outbreaks have been attributed to disturbed vaults infected a year before. But there is lack of accord in these observations, and analogy would make it doubtful whether this germ can survive for any lengthy period in a fecal medium.

What is the relation of this germ to *sewer air?* The disease has long been attributed to this source, but bacteriological study gives no ground for believing that sewer air plays any part whatever in conveying typhoid fever. The prolonged sewer air investigations of J. Parry Laws, extending over a period of three years (Report to the London County Council, 1893) failed under all conditions to find the bacilli, even when found present in the sewage. The challenge of a medical journal (*Western Reserve Medical Journal*, 1895,—in connection with a notable discussion in Cleveland), for the production of a single well authenticated case of typhoid fever contagion by sewer air met with no response. It is not probable that this germ is given off in sewer air.

Neither does it exist in the general *atmosphere.* Much has been said of this. But the idea of a typhoid-infected atmosphere cannot be entertained (Sternberg). It is a particulate body; dessication destroys it. Infection with it is not through the respiratory tract. It can only exist, transiently, in the atmosphere when lifted in particles of dust, and thereby conveyed direct to the digestive tract or to water or food.

What is its life history in *water?* That it will not live there indefinitely is agreed, but under favorable conditions it may live for months. These conditions are presence of pabulum, absence of heat and freedom from other micro-organisms. Edwin O. Jordan (*Medical News, Sept. '95*) found that in sterilized Lake Michigan water it retained vitality 93 days; in distilled water its greatest longevity was 18 days; adding B. coli, the B. typhi disappeared very soon. We may be sure that in water fairly free from hostile bacteria, whether in running streams impounded, or in wells, it retains life for a considerable period. Freezing does not affect it. This accounts for the winter epidemics of cities taking water from contaminated streams; the cold destroys or inhibits hostile bacteria. The conditions are diverse from those of soil infection and the consequent autumnal prevalence of the country.

In a large, newly-built institution, with every sanitary appliance and unconnected with the surrounding community, supplied with water from a great rapid stream which chemical and bacteriological analysis failed to find other than absolutely pure, an extensive outbreak of this fever developed, reaching all the buildings, domiciles and varied inhabitants of every part of it. The exclusion of all other possible sources of infection and the phenomena of its development all determined it to come from this water, which was potentially receiving typhoid excreta from a city in which the disease prevailed to an extreme degree one hundred miles away. The purity of the water, so far as the presence of other micro-organisms is concerned, and the rapid flow of the stream made this entirely possible. Details of this, and much other personal and collatable evidence, not within the scope of this paper, confirm the proposition as to the conditions of life in fresh water. These germs will also live for a time in water that is brackish, in seltzer water and the like.

I need not touch upon the life history of this germ in milk, where it finds its ideal environment, on soiled linen, etc. Our principal concern is its life in the soil, the atmosphere and the water.

The typhoid germ is ingested, not inhaled, and, save in the exceptional cases of ingestion with other unsterilized food, it always enters the system in water. Bryce puts the whole matter into an apothegm: In cities that obtain practically all their drinking water from a public supply whose source is beyond possibility of contagion, typhoid fever will practically disappear from the causes of mortality.

17 WASHINGTON AVENUE.

VIII. BACTERIAL AND ALLIED TESTS AS APPLIED TO THE CLINICAL DIAGNOSIS OF TYPHOID FEVER.

BY JOHN SLADE ELY, M. D.,

Professor of Histology and Pathological Anatomy in the Woman's Medical College of the New York Infirmary; Assistant in Pathology in the College of Physicians and Surgeons, New York; Pathologist to Bellevue Hospital.

Among the many valuable contributions of pathology to practical medicine none are, perhaps, of wider usefulness than those which make possible the determination of the etiological factor of an infectious disease during its continuance, when such evidence is often of the greatest value as finally determining the clinical diagnosis. A very widespread interest consequently attaches to the tests available for this purpose.

These, at the present time, involve three radically different lines of investigation. In the first place, the specific micro-organisms themselves may be sought in the dejecta, in the blood, or in the inflammatory products of the disease, and where, as in tuberculosis, the germs are given off in large quantities and with great constancy, this procedure may be both easy and of great diagnostic value.

Again, the diagnosis may be determined, not by the finding of the specific germs themselves, but by the detection of their products, the specific toxines elaborated by them in the course of their growth within the body. It must, at once, be evident that at present much greater difficulty attends this diagnostic procedure than the first, for our knowledge of these toxic substances and of their chemical relations is as yet but incomplete, and the long and complicated chemical processes required for their detection place them beyond the reach of the clinician.

A third diagnostic procedure, and one which would seem to be on the eve of a great development, is directed to the detection of certain substances in the blood and other fluids of the patient, which are apparently elaborated by the body in the course of its reaction to the specific bacterial products. With some of these substances, the antitoxins, we have already some acquaintance, and there is much in favor of the view that they are different in the different infectious diseases; are, in fact, almost, if not quite, as specific as the toxins themselves. But evidence is fast accumulating that these are not the only specific substances elaborated by the body in the course of these diseases. The recent researches of Pfeiffer, Gruber, Durham,

and others, have made it apparent that the blood of animals made artificially immune to cholera and typhoid fever, and the blood of patients sick with typhoid fever, possesses a remarkable power over the bacteria of those diseases when brought into contact with them in cultures, causing them to "agglutinate" and inhibiting their motility. If subsequent investigations prove this reaction to be specific in each case, and to occur with constancy in the disease, an important means of diagnosis will have been gained.

With these fundamental principles in mind, I will ask your attention to a consideration of the application which has been made of them to the diagnosis of typhoid fever. And first, let us inquire what may be hoped from efforts to detect the typhoid bacillus itself.

Almost the first effort of Gaffky[1] after he had finally established the etiological relationship of the bacilli to the disease was directed to the practical application of this discovery to diagnosis. With this view he examined the stools and blood of a number of typhoid fever patients in the hope of finding the bacilli, but always with negative result. Although the success of subsequent observers has been somewhat greater, and Pfeiffer,[2] Fraenkel and Simmonds,[3] Seitz,[4] Chantemesse and Widal,[5] Karlinski[6] and many others[7] have detected the bacilli in the stools at various times in the course of the disease, their failures have very greatly outnumbered their successes, and to-day one of the most noteworthy facts with regard to the disease is the relatively rare presence of its specific cause in the feces in sufficient quantity to make it readily detectable, although almost always finding its entry into the body through the alimentary canal.

In this connection it may be interesting to recall one of the most recent of these investigations, that conducted by Wathelet.[8] In the course of his study Wathelet made fifty-one separate examinations of the stools of twelve patients suffering from typhoid fever, more than 600 suspected colonies having been carefully investigated. Of these only ten colonies, from four of the cases, met the requirements of a positive identification of the typhoid bacillus, and these were found at only one examination in each case, though from four to eight examinations were made in each of the positive cases. Thus, of fifty-one separate examinations, the bacilli were detected in only four, or about 8 per cent.

But while these results of Wathelet have been quoted as fairly representative of the findings of the majority of those who have more recently investigated this question, it should not be inferred

that none have been more successful. Thus, Karlinski[6] has claimed the constant detection of the typhoid bacillus in the stools of numerous patients, but as his published results were obtained prior to 1890, and consequently before the requirements of a positive identification of the typhoid bacillus were well understood, they should hardly be accorded the same weight as the results of equally careful investigations by more recent observers. Furthermore, in the report of some examinations made with a view to testing the efficiency of Elsner's differential medium, Lazarus[9] and Brieger[10] both record the successful detection of the bacilli in the stools in a large percentage of the cases. Kruse,[11] also, in the very recently published third edition of Flügges "Microorganismen" mentions the fact that he has been successful in a considerable number of cases in cultivating the bacilli from the stools.

While, therefore, we must admit the possibility of detecting the typhoid bacillus in the stools of typhoid fever patients, we should nevertheless, appreciate the fact that the probability of such examinations being attended with success is relatively small.

The results which have rewarded similar examinations of the blood of patients suffering from typhoid fever, whether taken from the roseola spots or from the finger-tips, have been even more unsatisfactory, for, while it is indisputable that the bacillus finds its way into the blood and must be often present in it in very considerable numbers, all observers are agreed that it is by no means constantly present in that fluid. We have already noted the failure of Gaffky to detect the bacilli in the blood of typhoid fever patients, and similar results have attended the efforts of Fraenkel and Simmonds,[12] Seitz,[13] Chantemesse and Widal,[14] Lucatello,[15] Janowski,[16] Grawitz[17] and Merkel and Goldschmidt.[18] On the other hand, Rütimeyer[19] found the bacilli once in six cases in blood from the roseola spots; Neuhauss,[20] nine times in fifteen cases; and Thiemich,[21] four times in seven cases in blood from the same source; and Meisels,[22] Almquist,[23] Silvestrini,[24] Stern[25] and Flexner,[26] all report cases in which the bacilli were detected by means of cultures in the blood of the finger-tips or of the arm veins during the course of the disease. But, here again it should be remembered that these results were obtained before the exact requirements of a positive identification of the bacillus were fully understood, and it is quite possible, indeed probable, that in some of the cases in which positive results are recorded the germs would not have stood the more rigid tests required by our

more recent knowledge. However, even accepting these now questionable results as positive, the bacilli have been detected in the blood in a very small proportion only of the cases examined, and then only exceptionally in the course of the disease.

Examinations of the urine for diagnostic purposes have yielded somewhat more encouraging results, and there is reason to believe that, after the first few days of the disease, and with the aid of certain modifications in the method of examination recently suggested by Wright and Semple, the bacilli may be detected in the urine in a very considerable proportion of the cases.

But even the success of the earlier observers in detecting the typhoid bacillus in the urine was very considerable. Thus, Neumann[27] was able to find them by means of cultures in eleven of forty-six cases, and Karlinski[28] in twenty-one of forty-four cases (in one case as early as the third day of the disease), and they have also been detected in the urine by Seitz,[29] Koujajeff,[30] and Silvestrini.[31] The results, however, which particularly encourage the opinion that in examinations of the urine we may have a very useful means of the bacterial diagnosis of typhoid fever were reported in 1895 by Wright and Semple.[32] By the simple device of drawing the urine by catheter into sterile test-tubes and exposing it then to the body temperature in the incubator for twelve hours to permit of the multiplication of the few bacilli which may be present, these observers succeeded in detecting the bacilli in six of seven cases examined. As the result of this experience they are led to the belief that a few bacilli are practically always present in the urine after the first few days of the disease, and this, I may say, is in great part borne out by recent bacteriological examinations of the kidneys of persons who have died of typhoid fever, in which, in most cases, the bacilli have been found in very considerable numbers.

But, in contrast, again, to all this encouraging testimony we should not overlook the negative results of Chantemesse and Widal,[33] who report uniform failure as the outcome of their repeated efforts to detect the typhoid bacillus in the urine.

Of all the means of obtaining the bacilli from patients for diagnostic purposes none has been attended with such success as puncture of the spleen. This procedure is, of course, not unattended with danger, and is now considered to be rarely, if ever, warranted for the sake of diagnosis alone. It has, nevertheless, been undertaken in a very considerable number of cases, and with a high per-

centage of successes so far as the detection of the bacilli was concerned. Thus, Meisels[34] cultivated the bacillus in all of 9 cases examined in this way; Redtenbacher[35] in 10 cases; Phillipowicz[36] in 4 cases; Lucatello[37] in 10 of 17 cases; Neisser[38] in 11 of 12 cases; and Chantemesse and Widal,[39] Ali Cohen[40] and Guarnieri[41] also report successes. But here again there is slight conflict in the evidence, for Stagnitta[42] has failed to detect the bacillus in this way in all of 14 cases investigated.

Now, it must be evident that if bacterial analyses are to be of much real value in diagnosis it is indispensable that the germs be present with great constancy in some readily accessible fluid of the body or in the dejecta, and preferably during the early stages of the disease when diagnostic evidence is of most importance. It is also apparent from our review of the results which have attended such examinations in typhoid fever, that, if we except the spleen pulp and possibly also the urine, the typhoid bacillus is not detectable with sufficient frequency to render tests of its presence of much diagnostic value. Examinations may, of course, be undertaken in the hope of detecting the bacilli, but the likelihood that they will be rewarded by success should be understood to be small, and no particular diagnostic importance should ever be accorded to failures to find the bacteria.

But, for another reason also, examinations directed to the detection of the bacilli are of very limited diagnostic value—the positive identification of the typhoid bacillus is accomplished with very great difficulty.

The earliest studies of the typhoid bacillus disclosed its close resemblance to the ordinary colon bacillus, Bacillus coli communis, so abundantly present in feces, and the aim of the earlier investigators was to determine an available means of differentiating these two species. Subsequent studies have, however, shown the problem to be much more complex than was at first supposed, for, aside from the fact that no differential stain, applicable to the typhoid bacillus alone, has been forthcoming, they have shown that the number of closely allied germs from which the typhoid bacillus must be distinguished is very considerable. In the case of many of these a very long and complicated process of bacterial differentiation is required for the establishment of the identity of the bacillus. Thus, Flügge[43] includes no less than fifteen separate and distinct species in the group of typhoid-like bacilli, and, in addition, describes a

number of probably different varieties not yet definitely separable, under the title "Bacillus pseudotyphosus." Germano and Maurea[44] go even further, distinguishing as many as thirty distinct species of these typhoid-like bacilli. Of course, not all of these are liable to be met with in the dejecta and blood of persons suspected of typhoid fever, but a very considerable number of them are occasional inhabitants of the intestine, and are consequently liable to lead to uncertainty when the stools are examined for diagnostic purposes. In the urine the likelihood of the presence of other disturbing germs is much less, but even here one cannot be sure that a typhoid-like germ is in reality the typhoid bacillus, without a long and tedious bacterial analysis.

Some of the difficulties attending this analysis may be inferred from an enumeration of the tests which must be fulfilled for a positive identification of the typhoid bacillus, as recently stated by Loesener[45] after an exhaustive examination of the literature of the subject. His conclusions sum up the results of 689 separate articles in so far as they bear upon the cultural characteristics of the germ, with the result that ten characteristics are found to be distinctive of the typhoid bacillus, conformity with all of which is necessary to its positive identification. Briefly stated these are as follows:

1. The appearance of the superficial colonies in gelatine plates.

2. The very active motility.

3. The large number of flagella originating from all parts of the bacilli.

4. Decoloration by Gram's method of staining.

5. Growth on media containing grape, milk, and cane-sugar without gas formation.

6. Growth in milk without causing its coagulation.

7. Growth in proteid — containing media without generation of indol.

8. Production of acid when grown in whey, but not in excess of three per cent. as tested by one-tenth normal soda solution.

9. The growth on potato.

10. The failure to grow in Maassen's normal solution with glycerin.

As has been said, conformity with all of these tests is necessary to the positive identification of the typhoid bacillus.

In view of the complexity of this subject efforts have been repeatedly made to discover a culture medium which would either

support the growth of only the typhoid bacillus or on which the growth of the typhoid bacillus should be so characteristic as to be unmistakable. Though at first some of the culture media proposed for this purpose have given much promise of usefulness, they have for the most part been ultimately proved to be unreliable, and their use has consequently been abandoned. The most recently proposed of these media, Elsner's acid potato-gelatin containing one per cent. of potassium iodide, does, indeed, appear to serve a distinctly useful purpose in the separation of the typhoid bacillus from feces and from mixtures containing large numbers of bacteria of various kinds, for it has been found to support the life of only two other species liable to be met with under such circumstances, the Bacillus coli communis and the Bacillus fæcalis alcaligenes. [46] It is often of great assistance in a bacterial analysis to be able to separate in this way two or three species of bacteria from a mass containing many different species.

While it is not the purpose of this paper to discuss in detail the various means of identifying the typhoid bacillus, nor in this connection to more than indicate some of the difficulties attending this identification, I cannot leave this subject without brief mention of Pfeiffer's serum test, which, if the statements regarding it made by its discoverer shall prove correct, would seem to be a most reliable means of identifying the bacillus. And, furthermore, this test is of interest as having afforded the basis for an entirely new clinical diagnostic procedure presently to be referred to as Widal's serum test.

According to Pfeiffer,[47] the poison of the typhoid bacillus is intimately associated with the bodies of the bacteria, remaining in them even after the death of the germs. By the exhibition of small but increasing doses of this toxin, animals may be made artificially immune to the effects of fatal doses, and their blood is then found to possess decided bactericidal qualities as regards the typhoid bacillus, while it has no such effect upon the colon bacillus or other allied species. Pfeiffer's test then consists in mixing a portion of the suspected culture with a small quantity of the serum of an artificially immunized animal and then inoculating the mixture into the peritoneal cavity of an animal susceptible to the toxins of the typhoid bacillus. If the culture be of the typhoid bacillus, it will have been made innocuous by the antitoxins of the serum, and no pathogenic effect will result; but if it be of another germ than the typhoid

bacillus, the inoculation will be followed by the result characteristic of that species, as if the serum had not been used.

This test has been carefully studied by Pfeiffer, Gruber and Durham,[48] Widal [49] and others, and while some points regarding it are still in dispute it is now quite generally accorded much value in the identification of the typhoid bacillus. But it must be evident from its very nature that it can hardly have a wide field of usefulness since it requires for its application the serum of an artificially immunized animal, to obtain which a tedious process of animal inoculations is necessary.

It appears, then, that at the present time but little is to be expected from bacterial examinations as regards the practical clinical diagnosis of typhoid fever. For, to sum up what has already been said, the bacillus is by no means constantly present in the dejecta or blood of the patient, and when present is very difficult of positive identification because of our lack of any differential stain for it and of any simple method of determining its identity in cultures.

Thus the first and, as a rule, the most available of our means of detecting the presence of the specific bacteria in the body during the course of the disease fails us in the case of typhoid fever. But we are not therefore necessarily wholly without resource, for it will be remembered that two other general methods remain — the detection of bacterial products in the excreta, etc., of the patient and the detection of the specific reaction of the body to the effects of the bacterial poisons.

As yet but little attention has been paid to these procedures as of possible clinical diagnostic value, and I shall consequently have little to say regarding them. With the specific toxins of the typhoid bacillus we have practically no acquaintance. It is true that in 1885 Brieger [50] separated a poisonous substance from pure cultures of the typhoid bacillus, which he believed to be the specific toxin, and accordingly named "typhotoxin," but he has since been led to modify this opinion. And in 1890 Brieger and Fraenkel [51] detected a proteid poison in pure cultures of the typhoid bacillus, which produced death in rabbits in from eight to ten days. But up to the present time, owing to the many and great difficulties attending the separation of the bacterial poisons, we have but a slight acquaintance with their chemical reactions, and, while we believe them to be eliminated by the kidneys with great constancy during the course of the infectious diseases, we have no ready means of identifying them in that liquid.

When, now, we turn to the last of the resources under discussion in the diagnosis of typhoid fever, the detection of the specific reaction of the body to the bacterial invasion, two indications demand consideration, both to be found in the blood.

The first of these is the absence of the leucocytosis [52] so common in other infectious diseases. It has long been known that in lobar pneumonia, pyæmia and suppurative processes in general, in scarlatina, measles, acute lepto-meningitis, chronic phthisis, and a very considerable number of other febrile conditions, the blood contains an increased number of leucocytes, usually of the polynuclear variety. The most recent conception of this leucocytosis associates it very closely with the chemiotactic quality of the bacteria responsible for these various conditions, and we must, therefore, consider it as an expression of the reaction of the body to these bacteria. Now, the absence of leucocytosis is one of the most constant features of typhoid fever ; indeed, in many cases there is an actual diminution in the number of leucocytes in the circulating blood. But in this typhoid fever is not entirely alone, for in acute tuberculosis, malaria and typhus fever it is also exceptional to meet with leucocytosis. While, then, the absence of leucocytosis in any given case cannot be accepted as a final diagnostic indication of typhoid fever, it is, nevertheless, suggestive of that disease, and may be considered as important diagnostic evidence as between it and pneumonia or pyæmia. It is, however, to be remembered that in the event of the development of complications in the course of typhoid fever, more particularly if peritonitis or pneumonia arise, a decided increase in the number of leucocytes may be observed ; indeed, the appearance of leucocytosis in the course of an undoubted case of typhoid fever is regarded by Von Limbeck, Grawitz and others as strongly indicative of the development of a complication.

In my introductory remarks mention was incidentally made of the fact that recent researches of Pfeiffer, Gruber, Durham, Widal and others have developed the fact that the blood of persons suffering from typhoid fever possesses a remarkable power over the bacteria of that disease when brought into contact with them in cultures, causing them to "agglutinate" and inhibiting their motility. No sooner was this discovery made than attempts to make use of it for diagnostic purposes were undertaken by Widal,[53] and with such success that immediate and widespread interest was awakened in the test which has since been associated with his name.

This test, as originally proposed, consisted in the addition of serum

from the blood of a patient suspected to have typhoid fever, in the proportion of 1 to 10, to an actively motile broth culture of the typhoid bacillus. Such a culture, as is well known, is slightly cloudy, owing to the diffusion through it of the bacilli. On addition of serum from a typhoid fever patient to such a tube culture this cloudiness was found to quickly disappear as the result of settling of the bacilli, the supernatant broth becoming perfectly clear and the bacilli accumulating at the bottom of the tube as a light flocculent sediment. The microscope showed the bacilli to have lost their motility and to have become "agglutinated" into small clumps. Subsequent studies by Widal and Sicard [54] and by Johnston [55] demonstrated the fact that this peculiar inhibiting and agglutinating action is retained by the blood even after it has been dried for some time, though it was found then to be somewhat less marked, and at the same time a hanging-drop modification of the method was proposed, making it possible to avail of the test with much smaller quantities of serum and to watch its progress with the microscope. Widal's investigations soon attracted attention to the test and reports of its clinical diagnostic value rapidly accumulated, Achard,[56] Catrin,[57] Grünbaum,[58] Breuer[59] and others, almost at once confirming Widal's results. At about the same time Wyatt Johnston [60] instituted the employment of the test by the Montreal authorities for diagnostic purposes. This example was almost immediately followed by the New York Health Board, and it is to a very considerable extent the results of their experience with the test which will be quoted in the remarks which follow.[61]

As the outcome of all these studies several facts of interest relative to the test have been disclosed. In the first place, it has developed that the test is less absolutely specific than was at first supposed, the Bacillus coli communis and several other species of bacteria being at times similarly affected by the typhoid serum, but so far as its diagnostic value is concerned, this lack of an absolutely specific character is unimportant, since the observer is supposed in all cases to know that he is employing a pure culture of the typhoid bacillus. Unless this is clear the diagnostic value of the test is lost. Again, it has been found that the age of the culture employed for the test is of importance; that if the culture be older than twenty-four hours, the reaction is often indecisive. Finally, a proper dilution of the serum to be tested is essential, for it is well known that even the normal blood serum, when undiluted, possesses a decided germicidal action, and that this action is intensified in many conditions of disease. If, then, we are to judge of the specific agglutinating and inhibiting

action of any given specimen of blood, it is important that it be diluted to such a degree as to remove the possibility of interference with the test by this germicidal action. Fortunately, clinical experience with the test has shown the highest degree of accuracy when the reaction has been obtained with serum of a high degree of dilution.

Up to the present time all attempts to discover the ingredient of the blood in typhoid fever to which this peculiar inhibiting action is due have been unsuccessful. It has, however, been ascertained that it is not restricted to the blood, for it has also been observed in the milk, in urine, in tears, in pus and in serum from blisters. It is not bactericidal nor antitoxic, for the virulence of the bacilli, as tested by animal inoculations, is not lost. It is not contained in the corpuscles of the blood, for these have been carefully removed without impairment of the reaction. It is, then, something contained in the serum of the blood which may be secreted in the milk, tears, etc. From the fact that it is lost when the globulins of the serum are removed by precipitation and returns with their return again to the solution, it seemed that the substances to whose presence the reaction is due might be members of that group of albuminoids, but the fact that they are dialyzable throws doubt upon this theory.[62] While we must therefore admit that as yet the exact nature of these substances is unknown, it may nevertheless be inferred that they are a product of the reaction of the body to the infectious material, since they would seem to be absent from the blood of healthy individuals and to appear first in the blood of typhoid fever patients a few days after the onset of the disease.

But the question which particularly concerns us here is the value of this serum test as a clinical diagnostic procedure. This question can, of course, be definitely answered only after the accumulation of a large number of observations as to the occurrence of the reaction, and it is important that these observations should be so extended as to afford a knowledge of its occurrence in health and in diseases other than typhoid fever, since it must be evident that great diagnostic value can be accorded to a test like the present only when it is quite definitely restricted to the disease of which it is a diagnostic sign.

So great has been the interest in this test that already a very considerable number of observations regarding it are accessible, the results of the most important of which are included in the subjoined table:

TABLE OF RESULTS OBTAINED WITH WIDAL'S TEST UP TO THE MIDDLE OF JANUARY, 1897.

	Total No. of cases tested.	CASES OF UNDOUBTED OR SUSPECTED TYPHOID FEVER.					BLOOD FROM HEALTHY INDIVIDUALS OR FROM CASES SUPPOSED TO BE OTHER THAN TYPHOID FEVER.†		
		No.	Day of disease.	RESULT OF TEST.* Positive.	Negative.	Partial or doubtful.	No.	RESULT OF TEST. Positive.	Negative.
Widal[63]	280	80	4th—21st	45	35	....	200	0	200
Achard[64]	6	3	7th—12th	3	......	....	3	0	3
Catrin[65]	57	36	4th—41st	36	......	....	21	0	21
Haushalter[66]	39	39	7th—12th	27	12	....	......	....	......
Grünbaum[67]	40	8	10th—33d	8	......	....	32	16±	16
Durham[68]	4	4	8th—21st	2	......	2	......	....	......
Delepine[69]	40	30	8th—23d	24	4	2	10	0	10
Green[70]	25	11	16th—38th	11	......	....	14	0	14
Johnston[71]	164	129	2d—3d week	128	1	....	35	0	35
Brener[72]	70	43	6th—6th week+	43	......	....	27	4±	23
Chantemesse[73]	11+	11	11th—convalescence	11	......	....	+	0	+
Courmont[74]	11+	11	....	9	2	....	+	0	+
Stern[75]	16	16	9th—	16	......	....	+	1	+
Block[76]	37	37	10th—106th	20	......	17	......	....	......
Weinberg[77]	48	28	....	28	......	....	20	6±	14
Fraenkel, C.[78]	44+	44	2d—8th week+	34	10	....	+	0	+
Beco[79]	16+	16	....	11	5	....	+	0	+
Sabrazès & Hugon[80]	22	17	....	16	1	....	5	0	5
Jez[81]	11	4	....	4	......	....	7	1	6
Park, N. Y. City Health Board[82]	350	150	....	101	1	48	200	5‡	195
Thacher[83]	100	100	....	98	2	....	......	....	......
Le Fevre[84]	173	15	....	15	......	....	158	3	155
	564+	832		690 83%	73 9%	69 8%	732+	36 3%	697+ 97%

* Owing to ambiguity of statement on the part of a number of those who have reported results with Widal's Test, it is impossible to vouch for the accuracy of the numbers contained here in the columns headed "Negative" and "Partial or Doubtful." The total number of cases tested is usually stated, together with the number of positive results, but in many instances it is not clearly stated whether the subsequent development of cases in which a negative result was obtained showed them to be typhoid fever. Where this doubt has existed it has been thought safer to class these as cases of true typhoid fever, in which a negative reaction was given, and it is therefore probable that the negative results in cases of typhoid fever, as expressed in this table, are quite a little too high, the percentage of positive results being proportionately too low.

† A plus (+) sign in this column indicates that the observer named reports indefinitely as to the number of cases other than those of typhoid fever examined. A not uncommon expression has been the following: "Though many cases have been tested, the results have been uniformly negative." The ± sign indicates that in several of the cases included as positive the reaction was partial, doubtful, or, as in many of Grunbaum's cases, was obtained with undiluted serum. In some of these cases also the patient had had typhoid fever from four to forty years before (Weinberg, Grunbaum).

A glance at this table will show that in at least 83 per cent. of the cases of supposed typhoid fever tested, a positive reaction was obtained; and, on the other hand, that a positive reaction was obtained in only 3 per cent. of non-typhoid cases at the most. This is certainly a very high degree of accuracy, and would seem to warrant the accordance of great diagnostic value to the test.

Of course, many questions regarding the reaction are still unsettled, and, until they are definitely answered, the final position of the test among diagnostic procedures must be in a measure uncertain. One of the most important of these is as to the time at which the agglutinating substance makes its appearance in the blood in sufficient quantity to insure the reaction. In two of the recorded cases (Johnston,[85] C. Fraenkel[86]), this has occurred as early as the second day of the disease, and, if further tests show similar results, we shall have a diagnostic sign of great practical value. But, conversely, if it shall develop that the reaction is not, as a rule, present until the end of the first week, or even later, in the disease, it must be clear that the value of the test will be distinctly less, since by the end of the first week the symptoms are usually sufficiently developed to permit a diagnosis. Up to the present time very few positive results have been obtained in tests made prior to the sixth day of the disease.

Again, the relation of the reaction to other diseases than typhoid fever must be ascertained. Thus far distinctly positive results have been noted in cases of pneumonia (Park,[87] Le Fevre[88]); in diabetes (Park[89]); in jaundice (Grünbaum,[90] 3 cases); in tuberculous meningitis (Jez[91]); in septicæmia (Ferrand[92]); in carcinoma ventriculi (Le Fevre[93]), and in otitis externa (Stern[94]). Furthermore, Park[95] mentions a decided positive reaction in the case of three negroes, suffering, respectively, from gangrene of the toe, from acute phthisis, with irregular fever, and from supposed tumor of the colon, with fever (104°) which subsided after exploratory laparotomy.

And finally, certain details of the reaction itself must be studied with a view to determining the best mode of its application, and just what is required for a positive result.* Thus, the time of com-

* While this article is passing through the press an important contribution to our knowledge of many of the details of the reaction has appeared from the pen of Wyatt Johnston and D. D. McTaggert (*Montreal Medical Journal*, *March*, 1897). They find that results obtained with an attenuated culture are more reliable than those with a more virulent culture; that with an attenuated culture the dried blood method is very accurate; that the degree of dilution is less important when an attenuated culture is employed. Their paper concludes with these words as to the requisites of a positive reaction: "We do not think that anything less than complete clumping and total arrest of motion obtainable by the dry as well as the moist test in a young attenuated culture should be regarded as typical."

mencement of the reaction after the mixing of culture and serum must be more definitely ascertained. The majority of observers record the almost immediate commencement of the reaction in marked cases, but in some cases, on the other hand, a reaction, which must be distinctly classed as positive, has been seen to occur only after several hours. The qualities of the culture best adapted to the test must also be determined; whether a virulent or an attenuated culture lend itself better to the test,[96] and what is the best culture medium, etc. It is already generally conceded that the culture actually employed for the test must not be older than 24 hours, and must show active, though not necessarily violent, motility.

Again, as regards the best source of material for the test, as to the advisability of drying it, and as to the most desirable degree of dilution, much must be learned before the test can assume a place among thoroughly reliable diagnostic procedures. The outlook for it is exceedingly encouraging, but until more perfectly understood, the exact degree of its diagnostic value must be considered as *sub judice*.

If, then, we bring together the conclusions to which we have been led by our study of the present status of bacterial and allied tests as applied to the clinical diagnosis of typhoid fever, we find them to be as follows:

1. Bacterial examinations of the stools, blood, urine, etc., are unsatisfactory for the reason that such examinations must be undertaken with but little promise of success, owing to the uncertainties connected with the detection of the bacilli in these fluids, and to the great difficulty of positively identifying the typhoid bacillus.

2. Up to the present time our knowledge of the toxin of the typhoid bacillus is too meagre to give to tests for its presence any particular diagnostic significance.

3. Widal's serum test promises, when better understood, to become an important clinical diagnostic test of typhoid fever.

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IX. TYPHOID FEVER IN INFANCY.

BY W. P. NORTHRUP, M.D.,
New York.

By infancy is here meant the first two years of life, and the discussion will be limited to the relation of that period to the infective agent of typhoid fever.

Are infants vulnerable ?

My answer is, but little vulnerable. Sporadic typhoid fever is a rare disease in the first two years of life. As the food of infants is largely milk and water, this phase of the subject under discussion has an importance.

Some reasons for believing that typhoid fever in infancy is rare appear in the following.

At the New York Foundling Hospital, in twenty-five years, there is no record of or remembrance of a case. This statement is made on the authority of Drs. O'Dwyer and J. Lewis Smith.

In my own experience of fourteen years at the same institution, clinically, no case has been seen. I may add that from my first entrance into the service, Dr. O'Dwyer and myself have been literally looking for it. Furthermore, in 2,000 autopsies upon subjects under three years of life, for which statement I am personally responsible, no typhoid fever was verified.

Of the 1,800 infants and children usually under the care of the institution, 1,100 are out at nurse in the environs of New York, Staten Island, Hoboken, Jersey City, Westchester county, Astoria, Williamsburg, Long Island City, and intervening points, beside the crowded parts of New York and Brooklyn. All these are under three years, and a majority under two years. For the most part the food of these children is milk and water. Above the first year probably the milk is not warmed, to say nothing of boiling. Children drink copiously of water. There have been now 25,000 infants from the Foundling Hospital living about among the community and no case has returned with recognizable typhoid. They are not specially protected, but rather unusually exposed. Let it be remembered, too, in this connection, that our large hospitals receive their full typhoid crop of adults from just these localities, not a few of them finding their way to my own service at the Presbyterian Hospital. A child over one year old will receive from her ten-dollar-a-month nurse many delicacies (*sic*), but the milk will be

the main feeding, and that milk will often be procured at the corner grocery. Corner-grocery milk is almost a by-word for unreliability.

After watching for twelve to fourteen years for a case of sporadic typhoid in infancy, I entered into an investigation with other institutions. I will refer to one. The New York Infant Asylum in eight years has not had a case of typhoid, 10,000 cases of illness having been observed in that time and 700 autopsies made (Holt).

From the experiences of the New York Foundling Hospital and the New York Infant Asylum the statement seems justified that typhoid fever in the first two years of life is rare.

On the other hand, in the presence of overwhelming infection (over abundance of virulent bacilli in long continued contact), an infant, though naturally little vulnerable, may succumb to the epidemic infection. In the Stamford (Conn.) epidemic, in which 406 individuals were attacked, I saw four infants sick of undoubted typhoid: four in four hundred and six. One was thirteen months old, one of three in a household of four attacked, all having typical typhoid. The manifestations in this infant were fever, prostration, dry tongue, pallor, characteristic eruption, feelable spleen.

One was sixteen months, two were twenty-two months; of the latter age (twenty-two months), one died early in the disease with broncho-pneumonia.

This is the only autopsy on a typhoid patient under two years of age I have ever made or have seen. The features of the case were direct exposure to "the milk," characteristic fever, tongue, eruption, spleen, diarrhœa, swollen Peyer's patches and mesenterics.

"The milk," as it was denominated, was distributed by one man to a poor part of the city. It was a cheap milk, and the consumers were of a prolific sort; large families abounded. In this epidemic a certain well, under the same roof with the wagons and cans, was believed to be intimately associated with the infection of the milk distributed.

It will be urged that the unusually careful management of milk designed for infants, its warming and sometimes its boiling, have much to do with the rarity in this period of typhoid. That may be true. Infants under one year are largely wet-nursed too. Above one year I think it is the experience of most that the infant is given largely unboiled milk; they prefer it and are considered large enough to take it. Especially is this so in the associations from which the above experience has been gathered.

My purpose in this paper is to set forth conclusions already formed, and to ask you to subject them to further test by newly acquired methods of exact diagnosis, viz., the serum test.

In conclusion, I would say, the vulnerability to typhoid infection is slight in the first two years of life. In continued contact with an abundant, virulent infective agent, such as occurs in epidemics, an infant's ability to withstand may be overcome.

In infancy sporadic typhoid is rare.

57 EAST 79th STREET.

X. MEDICINAL AND DIETETIC TREATMENT OF TYPHOID FEVER.

BY WILLIAM S. ELY, M. D.,

Rochester, N. Y.

The preceding papers are of great value in giving us much information concerning the causes and prevention of typhoid fever, but who can tell us anything new about its treatment? Every physician of experience knows, or *thinks* he knows, how to treat typhoid fever. The majority of his cases have recovered, and friends and patients laud his skill.

When I commenced practice, nauseous fever mixtures, turpentine and quinine, whiskey and brandy, with close air, an abstinence from water, and disregard of diet, constituted the approved method of treatment of the disease under consideration. Even then the majority of the patients survived.

The profession was slow in discarding a system of medication taught in the text-books and, *ex cathedra*, in the medical schools, and I still remember wondering whether it would be safe to omit turpentine internally for a dry tongue, or externally for a swollen abdomen. *Medicina* "*non facit saltum*" has been true of our therapeutic progress. It has been by slow degrees that we have become convinced that the function of the physician in the management of self-limited diseases is to modify symptoms which he cannot arrest, and to guide the patient safely to the haven of health, as a skilful captain steers his ship across the sea.

The discovery of the bacterial origin of typhoid fever has stimulated the study of its management, in the expectation that by the destruction or neutralization of a specific germ its deleterious

influences may be arrested or modified. While this is our hope and aim, and may be confidently anticipated in the future, we are not yet in a position to declare it "*un fait accompli.*" The strong hopes of aborting typhoid fever by the "Woodbridge treatment" have not been realized in the experience of many of those most anxious to establish its value. It is but just to Dr. Woodbridge to say, that he deems the failure to obtain his flattering results to be due to an incomplete comprehension of his elaborate method. Hence, his treatment should be accorded further trial.

When the little square boxes of coal-tar derivatives came to us from across the sea, with such wonderful endorsements of their ready acceptability to the palate and stomach, and of their harmless antipyretic effects, how these products were thrust upon our patients, and with what delight we saw the mercury in our fever thermometers tumble! It now seems singular that it took us so long to measure the harmful reaction of these remedies, in the form of nervous depression and heart failure. I do not question the potency of these agents, but I desire to emphasize the belief that they must be used in smaller doses than formerly, and that their effects must be closely studied.

It appears demonstrated that the diarrhœa of typhoid fever is a salutary influence, carrying off noxious bacteria, and lessening the septic infection which they seem to favor. Therefore, the laxative usually given early in the disease may often be continued, with good effect, in the form of a saline.

There is reason to question whether the so-called "fever mixtures" do sufficient good to compensate for their disturbing influence upon digestive processes. Nor is there any agreement in favor of guaiacol, salol, carbolic acid and iodine, chlorine water, and so many other vaunted remedies that might be named. They serve to satisfy the friends of patients that something is being done, but I am led to question their real efficacy. Why should I argue for their potency, when I know that the speaker who follows will throw cold water upon them all? He will show that the external and internal use of water are the best antipyretics yet known. We are then left, in ordinary uncomplicated cases, to place our main dependence upon hygienic conditions and dietetic treatment. Whatever else may be required, fresh air and pure water must be abundantly supplied.

I usually aim to place a typhoid fever patient between two open windows, and the fear of taking cold is a bogey to be expelled from

the minds of the patient and his friends. Whenever possible, two single iron beds should be supplied, the bedding of the one not in use being left in the open air for from four to six hours daily.

The bed-pan often excoriates the sacrum. I have seen terrible bedsores, compromising the life of the patient, follow its use. Hundreds of times, in single cases, this instrument of torture is shoved under emaciated hips, and the skilful nurse must feel for the helpless patient, who soon becomes oblivious to its employment. She has learned to cover the bed-pan with pads of cotton wadding, to be burned after use, and she changes the position of her patient almost hourly from side to back, and from back to alternate side, upon the softest bed she can construct. Thus, the discredit of an extensive bedsore, or great praise for preventing the occurrence of the same, may be due to the nurse. She will remember that there is danger wherever there is prolonged pressure, not alone in the region of the hips, but also about the shoulders, elbows and ears. In bad cases, with brain symptoms, when the patient's eyes are fixed and open, the nurse will frequently move the eyelids over the cornea, to prevent dryness and ulceration of the same.

We do not give internal remedies to moisten the dry tongue of a mouth-breathing typhoid fever patient, or to lessen the sordes upon his teeth ; but we expect the nurse to modify these conditions by frequent cleansing and soothing lotions.

In intestinal hemorrhage, often followed by a sudden fall in temperature, we note a condition always serious, and occasionally fatal. It may be treated by five-grain doses of alum largely diluted with water, frequently repeated, by ice upon the abdomen, and by stimulants p. r. n. When there are the pain, shock and collapse, which may indicate intestinal perforation, the skilful surgeon must be called in consultation, and the question of immediate laparotomy is to be decided.

I believe there have been, and will continue to be, cases of typhoid fever, due to an intense septic influence, which will prove fatal under any treatment known at present. They are like septic diphtheria, septic scarlatina, septic pneumonia, and other septic states of the system, in which the poison of the disease is so excessive in amount as to paralyze hopelessly the nervous system.

Stimulants have been used injudiciously in typhoid fever. I am always distrustful of the result in a case which cannot survive the first week without stimulants. Defer them until the second or third

week of the disease, or later. They are a powerful agent in reserve for the exhaustion of pyrexia, and for the depressing influence of the fever poison upon the digestive and nervous systems. Begin with camphor water in half-ounce doses, every two or three hours, and lead up to the milder alcoholic stimulants, as sherry or red wine, with whiskey or brandy to fall back upon. The use of all should be determined by the effect upon the pulse, temperature, respiration and nervous condition. Strychnine is of great value in many cases, and may be given for days in frequent doses, providing you have a competent nurse to watch for its cumulative effect.

As to dietetic treatment, the profession is now generally agreed that liquid food is nearly always preferable, and that in the average case there is no substitute for milk in some form — plain, boiled, peptonized, with lime water or soda, according to the indications. Two quarts a day is a minimum amount for the average case. My patients have not been disturbed by its regular administration by night as well as by day. Indeed, I never make any difference between night and day in the management of serious cases of typhoid fever. Rebellious stomachs, as in some other diseases, are to be managed rather than medicated. An amount of milk given every three hours and rejected can be given in divided portions every hour, or half hour, and be retained. I once saved a patient's life by slipping one half-ounce of nourishment into the stomach every fifteen minutes — ninety-six times each twenty-four hours — for several days. Larger amounts at longer intervals invariably caused vomiting. As nervous force is rapidly consumed by persistent high temperature, its duration must determine the amount of food given. Milk may often be supplemented by beef juice and eggs. In exceptional cases where exhaustion has been marked, I have given twenty whole eggs, or the whites of forty eggs, every twenty-four hours, with benefit.

What is needed is *judgment* in conserving the vital forces of the patient and in treating complications as they arise. Statistics of medication are valueless, unless the type of the disease be considered. Age, constitution, habits, previous history, climate and local surroundings, necessarily modify treatment and its result. The distance is antipodal between ambulating typhoid fever and the profound septic case, which paralyzes the whole system long before the disease can reach the midocean of its course. Judgment, I say, is required to generalize the disease, and to individualize the patient,

to measure accurately the conserving and destroying forces, from visit to visit, and to adjust the management of each case by the indications thus obtained. *Non nocere* should be our motto.

Do these views savor of nihilism in the therapeutics of typhoid fever? I reply that where there is no agreement whatever among physicians in the use of numerous remedies in a self-limited disease, it may well be asked whether they have an unquestioned value.

But, in conclusion, if I underrate mere medicinal agents, I cannot exaggerate the importance of hygienic and dietetic measures. In the truest sense we *cure* our patients by caring for them. They are often helpless, indeed, lapsing into the oblivion of infancy, and are wholly at our mercy. Are we not criminally negligent if we do not give them our most intelligent care? Until we have learned successfully to abort the disease, or have found an antitoxin for it, I repeat, that we must depend mainly upon hygienic and dietetic measures, with the free use of water externally and internally, and the guarded employment of those medicinal agents which have proven most trustworthy in the physician's individual experience.

I have been well satisfied with the results obtained in my practice from the application of these principles. And it is principles of treatment rather than specific medication, that I have aimed to suggest in a necessarily limited abstract. I should deem it presumptuous to do more than this.

Lastly, let me emphasize the great importance of the aid rendered by an intelligent trained nurse, in every serious case of typhoid fever which we are called to treat.

78 SOUTH FITZHUGH STREET.

XI. THE EXTERNAL AND INTERNAL USE OF WATER IN TYPHOID FEVER.

BY CHARLES G. STOCKTON, M. D.

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The question to which it is especially desired to call attention in this brief sketch is: What may we hope to gain by the external and internal uses of water in the relief of those morbid conditions which prevail in typhoid fever? It is not simply the question of reducing the temperature, for it cannot be too strongly insisted that while the

temperature is an extremely important and constant accompaniment of these states and changes, it is far from being the most serious or the most important of them. In fact it is to be regarded, both in its rise and reduction, as only an index of the more important and active conditions which are going on deep in the interior of the body. So constant and accurate an index is it, indeed, that we can hardly wonder at the error of Jurgensen and others in supposing it to be the chief morbid factor and source of danger, but it is proper to protest against any such position being accorded to mere hyperpyrexia, either as a source of danger or a point of attack. So far as the mere reduction of temperature is concerned, the Brand method offers probably little advantage over the antipyretic drugs, and its immense superiority lies largely in the effects it has upon the underlying factors.

Let us briefly review the conditions present in the typhotoxic state. First of all, we have a profound vascular paresis, particularly of the arterioles, capillaries and veins, and consequently a literal stagnation of the blood in these vascular swamps, both external and internal, and in the lymph spaces of the tissues. Next we have a disappearance from the circulating blood of numbers of both the red and white corpuscles, due apparently in part to their migration into the tissue spaces, and in part to the marked destruction, particularly of the red cells, resulting from the fever and accompanying toxemia. That this does actually occur is shown by the experiments of Jacquet, who finds that in typhoid fever both the red and white cells are markedly diminished in the blood-count. Next in probable importance is the great lessening and even crippling of the natural excretory mechanisms, particularly the kidneys, bowels and skin, which appear to be closely dependent upon this vascular stagnation. Following this we have an immense accumulation of toxic materials in the blood from at least three distinct sources, the natural waste products of the body which are of considerable amount, even in the resting condition and low diet of the typhoid-fever patient; next the toxins produced by the life-activities of the germs and their reactions upon the body cells; and last, but not least by any means, the autointoxication from the putrefactive changes which take place so profusely in the alimentary canal, of which the characteristic typhoid-stool is the only illustration necessary. Finally we have direct focal infection of localized masses of the tissues in kidneys, spleen, etc., aggravated by the heaping up, as it were, upon them of these toxic

products from the stagnation of the blood and lymph-current. It is especially desired to emphasize the disastrous effects of this stagnation of the toxin-laden fluid in the engorged lymph and tissue-spaces, for here is where the blood plasma is actually absorbed, and, so to speak, fed upon the tissues. The literal, actual food of the tissues is the part of the blood-mass which is most intensely poisoned.

Now as to the question, what effects can we hope to produce by the use of cold water upon these morbid conditions? First of all it is to be noted, that the effect is produced not so much by the mere exposure to cold water, *en masse*, as by the method in which it is brought into contact with the surface—not so much by an inherent property of cold or cold water, as such, but by the stimulus evoked by its sudden impact upon the nerve endings of the skin; and this effect will be largely dependent, first upon the temperature, and second upon the manner of its application. The effectiveness of the result will be found to depend more upon the *method in which* the cold water is applied than upon its temperature, its amount, or the length of its application. And even at the risk of tiresomeness, it is desired to emphasize this fact by a brief reference to the essential elements of the Brand method. That this should be necessary at this late date seems almost incredible, and yet so often do we hear the Brand method blamed for the results in certain cases, in which upon even a cursory investigation, we find that the line of treatment was, in its essential features, anything but that so ably advocated by Brand, that we feel justified in this course. In many of these cases the essential element in the method of the application of cold water, as laid down by Brand, was entirely neglected, and the fact of cold water being used is often the only element of similarity in the two processes. To call many of these "modified" methods by Brand's name is, as urged by Baruch, unfair and misleading. The essential elements of the Brand treatment I regard as three in number. First, that the patient is plunged into distinctly cool or cold water; second, that friction is actively maintained during his immersion so as to keep up the tone of the vessels of the skin; and third, that the immersion is continued until a general reduction of the temperature, and not a mere superficial one, is effected, as shown either by the thermometer or by the production of slight chattering of the patient's teeth, except, of course, in the event of symptoms of too great depression occurring before this point is reached. Then to repeat the bath every three hours as long as the

temperature rises above a certain point ($102\frac{1}{2}°$ F.) The principles of its action appear, roughly speaking, to be, first, that we obtain a powerful stimulation of the entire vaso-motor mechanism, and particularly of the tone of the skin-capillaries, and through these that of the central nervous system, by the initial shock by the contact with cold water. Second, that this shock is prevented from becoming extreme, and the prolonged cold from producing spasmodic contraction of the skin-vessels by the amount of friction which is administered. Third, that the patient is kept submerged until, practically speaking, the entire blood of the body has had time to be pumped through the cool and active surface-vessels and the temperature of its entire bulk has been reduced. The first result upon the morbid symptoms is seen in the prompt relief of the stagnant congestion of capillary circulation in both skin and the great viscera. The piling up of corpuscles in the liver, which Jacquet has reported, is checked, and the blood is lowered in its specific gravity by permitting the contents of the lymph-spaces to drain back into the vessels. The last action probably also accounts for the marked improvement in another morbid condition, viz., the rapid increase of corpuscular elements in the blood, particularly of leucocytes, which the researches of Billings, Thayer, and Jacquet have proved to be such a striking result of the use of the cold bath. These observers attribute this result, not so much to an increased production of the cells, as to their return to the blood-channel from the lymph-spaces. The characteristic hypoleucocytosis, which is so well marked in typhoid fever as to be of no small value as a diagnostic sign, is strikingly diminished by the cold bath.

As to the effect upon the general toxemic conditions, no better illustration can be given than the changes in their unvarying index — the temperature — which are vastly greater by this method than by sponging or by any of the so-called " modified " forms of the hydriatic treatment. It is believed that its superiority in this respect is hardly adequately recognized. The recent statistics of Cabot in the Massachusetts General Hospital upon a total of some three thousand cases, give the average temperature-reduction by the sponge bath as four-tenths of a degree Fahrenheit; while the average reduction by the plunge or Brand method is two and four-tenths degrees, and not only greater, but much more persistent than the smaller effect of the sponge method. Hence, we feel justified in insisting that this method, if adopted at all, should be followed in its entirety, as re-

peated experiences have now accumulated to show that no other method is to be compared with it in the effectiveness and permanency of its results. One of the most important elements in its effect is that reported by Ausset, who found that not only was the flow of urine increased by the cold bath, but that its toxicity was more than doubled within a few hours. The value of this result alone, in relieving the poisoned stagnation throughout the entire system, can hardly be over-estimated. What the results of the method are, it is hardly necessary more than to enumerate before this audience. First, and most striking of all, but valuable chiefly only as an indication of deeper and more essential improvement, is the marked lowering of the temperature. Next, and almost equally striking, is the soothing and calmative effect upon the nervous system, the relief of delirium, and the production of refreshing sleep, a gain of incalculable importance in a long-fought siege like typhoid, the restoration of the moist and natural condition of the skin, signalizing the resumption of its normal excretory action, the slower, fuller and more elastic pulse, the improved appetite, and, in fact, the reduction of all characteristic features of the well-known typhoid state to a minimum, which comes at times almost to the disappearance point. I doubt, seriously, whether a typical photograph of the "typhoid state" could be taken at any time during the course of a majority of cases under the Brand treatment. And the treatment is as safe as it is effective.

In my experience there are only two conditions which can be regarded as contra-indicating the full method. These are marked renal complications or the occurrence of intestinal hemorrhage. By the presence of renal complications I by no means refer to mere traces of albumen and casts in the urine, for these I believe will be found to be present in nearly ninety per cent. of all cases of typhoid. It is only a question of searching carefully enough to discover them. Nothing short of an inflammatory involvement of the renal epithelium is sufficient to prevent the use of the Brand treatment. The objection to its use in hemorrhagic cases is that of increasing the blood pressure in the internal organs; and in both these cases we may hope to reach fairly satisfactory, although not as powerful, results by the skillful use of hot baths. In the renal disturbances this is accomplished by stimulating the surface circulation and increasing the excretory action of the skin and, to some extent, relieving internal congestion; while in hemorrhagic cases something of

the same effect may be produced, and any unnecessary disturbance of the patient avoided, by the use of the hot mustard foot baths. Contradictory as it may seem, an improvement in the tone of the superficial blood-vessels may be produced by the sudden application of either hot or cold water, and the paralysis of this tone by undue persistence in either.

To the problem, how these effects are produced, but the briefest reply will be attempted. Late authorities are agreed that the chief factor is not the mere mechanical reduction of the temperature, as such, but the marked improvement in tone, first, of the peripheral cutaneous and then of the general vascular system. This it is that drains and empties the engorged lymph-spaces of their poisoned food material, that relieves congestion in the hepatic and pulmonary circulation, that throws the full volume of blood through the anæmic, paralyzed kidneys. But just how this is brought about, and in what this improvement in tone consists, is still in doubt. The fact that the local constringent effect upon the vessels of the skin is promptly followed by a rapid reactionary dilatation is as familiar as the alphabet. But just why this reaction should so immensely improve the quality of the heart's action and relieve the toxic drowsiness of the whole nervous system is as yet hardly adequately explained. It is usually accounted for, simply upon the ground that it relieves the work of the heart by dilating the skin vessels and diminishing the peripheral resistance. But Winternitz observes, what a glance at the flushed skin of the fever patient would immediately suggest to the eye, that we have already a distended condition of the peripheral blood channels due to paralysis of the vessel-walls, and insists, in flat contradiction to the other explanation, that the heart's action is improved by the restoration of resistance in the peripheral circulation. It has been suggested, by Woods Hutchinson, that very probably the fundamental element in this so-called "improvement of the tone" in the superficial vessels, the appearance of which all investigators agree upon, is really an active and not a passive one, a local rather than a reflex change. In other words, that the normal condition of the muscles in the walls of the arterioles, as elsewhere, is not one of rest either in contraction or dilatation, but of constant rhythmic activity, and that the restoring of this active contractivity in the vast mesh of vessels in the skin, by the contact of the cold water and by friction, is the essential element in the improvement of the circulation, and my own observations have led me to practically the same

conclusions. The heart itself is, Hutchinson urges, nothing but a special local aggregation of these same muscular fibres, and like them, its action is intrinsic and merely regulated by the so-called cardiac nerves; and, when we recall that the great contractile mesh of the cutaneous vessels is capable of containing over sixty per cent. of the entire blood of the body, and that the whole of this surface is affected by the cold bath, it hardly seems impossible that the stimulation of this great, diffuse "skin-heart," may be a factor of the greatest importance in improving the entire circulation. Once this active addition to the total force of the circulation has been effected, the relieving of the lymphatic stagnation in all the tissues and organs follows rapidly. The nervous system, rid of the torturing poisons with which it has been saturated, most rapidly feels the relief. Sleep now becomes possible, and is simply the beginning of the benefits which will flow from this gain. The digestion is distinctly improved, by the relief of the portal stagnation, and another important line of connection with the relief column is opened up. The marked improvement in the nerve, determination and courage of the patient is but a striking symptom of the similar change which is taking place throughout the whole organization, and is of itself an immense gain in the struggle back to health. The kidneys are flushed by an abundance of blood, which both nourishes and stimulates them to increased excretory fforts. The glands of the skin, freed from the singular choking effects produced upon their excretory ducts by the lymph stagnation in the surface tissues, resume their activity, and, according to Quirolo, the toxic properties of the sweat of fever patients are almost as well marked as those of their urine, and so the entire situation is modified in the right direction. Nor is it simply a question of increasing the per cent. of the patients who escape with their lives. The proportion of those who emerge from the encounter, only half alive, is even more strikingly diminished. The serious complications and the permanent disabilities of the heart, of stomach, or of brain, which were so distressingly common after typhoid, treated by the old methods, are even more markedly reduced than is the death rate. And all this credit needs to be offset only by one item on the debtor side, and that is the quite frequent occurrence of a transient neuritis of the feet, the so-called "Brand sore toes." This result, which was first reported by Osler, and has also frequently been noted in the wards of the Buffalo General Hospital, is somewhat inexplicable, but in no case has it led to any permanent disability.

Of the internal use of water, it need only be said that it furnishes a valuable adjuvant to the external application. Its results may be briefly summarized as follows: It washes out the intestines, mechanically as it were, and thus diminishes the auto-intoxication. Passing into the portal circulation it flushes the vessels contained in this system, and also by its lower temperature possibly produces something of the same stimulating effect upon the intestinal and portal vascular systems that is produced by the bath upon that of the external surface. It immensely increases the flow of water through the kidneys, Baruch reporting, in some cases, an increase of three hundred per cent. in the amount of the urine passed within twenty-four hours after the adoption of the method. It also lowers the specific gravity of the blood primarily, and thus diminishes its toxicity, while, by a curious secondary effect, it increases the amount of corpuscular elements as recent experiments have shown. It is most commonly administered by the mouth in doses of from six to eight ounces every two hours; in fact, pushed to the extreme drinking-limits of the patient, so that from three to four, and in some cases five, quarts of water during the day may be administered. In severe cases, or in later stages, the subcutaneous injection of large amounts of the normal saline solution will be found very effective, and large "high" enemata of either hot or cold water, the so-called colonic lavements, will also be found of service.

436 Franklin Street.

XII. DISINFECTION OF TYPHOID EXCRETA.

BY W. GILMAN THOMPSON, M. D.,

New York.

I have been invited to discuss the importance and practical methods of disinfection of the excreta of typhoid fever patients. It seems elementary, however, to argue before this society the importance of this subject. No truth of bacteriology is now more firmly established than that of the causative relation of the bacillus typhosus to enteric fever. I will, therefore, merely emphasize the well-established facts that the typhoid bacilli can only leave the body of the patient in the alvine dejecta; that the stools become more and more infectious after evacuation; that the virulence of the enteric contagium may be preserved undiminished for months outside of the body; and that while its activity may be temporarily suspended by cold

drying or other conditions, it is promptly restored when the germs reach the favorable environment of the small intestine. The germs have been found to live for three months in unsterilized stools of typhoid fever patients (Ueffelmann), and they have been kept alive for two years on potatoes, on sterilized linen for over two months, on sterile garden soil for three weeks (Pfuhl), and Ueffelmann has kept them alive for five and a half months in common earth. They have been kept dry for two months without loss of vitality.

It has been stated that the bacilli only leave the body through the medium of the stools, but according to Dreschfeld (Albutt's System of Medicine) they are not infrequently found in the urine, and they have been obtained exceptionally from the sputum of typhoid patients. One bacteriologist claims to have found them in the urine of twenty-five per cent. of cases examined; another in six out of seven cases. In this country it has not been customary to regard the urine as a source of infection, but if these observations be confirmed, it should be disinfected in the same manner as the stools, pure corrosive sublimate or carbolic acid being added in sufficient strength to make the urine a 1 : 1,000 or 1 : 20 solution as the case may be.

In the destruction of the bacilli of enteric stools, the use of all proprietary germicides should be discouraged on the ground that their expense is apt to restrict their free employment, while they are less reliable than ordinary disinfectants.

Besides strong heat, of the many disinfectants available, there are but three, corrosive sublimate, carbolic acid and lime, which commend themselves to serious consideration, although one or two others will be briefly mentioned.

Corrosive sublimate is by far the most efficient disinfectant of typhoid stools which we possess, when it is properly applied, as a 1 : 50,000 solution, promptly destroys the bacilli in culture media, but in disinfecting solid fecal masses it should be rendered acid, for the albumin present in the stools precipitates the mercurial as an albuminate before its germicidal action is complete. It is, therefore, desirable to add crude hydrochloric or sulphuric acid as in the following formula:

℞ Hydrargyri chloridi corrosivi,	1 oz.
Acidi hydrochlorici (commercial),	½ oz.
Aquae,	4 gals.

Unfortunately, both the corrosive sublimate and the acid are highly destructive to all metallic pipes and closet fixtures, and for this reason their use in hospitals where many cases are treated may seriously damage the plumbing. In a private house, with but a single case, this is less apt to occur if the precaution be observed of flushing well the pipes. Corrosive sublimate is a good germicide for use in military camps, for, owing to its disinfectant strength, it occupies comparatively small bulk in transportation. The fact that it is so highly poisonous need not make it less desirable than other disinfectants, for they are all poisonous if carelessly handled. The colorless, odorless solution has sometimes been mistaken for drinking water, but the addition of a little indigo or litmus will make this fatal error less liable to occur. When added to typhoid stools for disinfection, corrosive sublimate solutions should be in strength of not less than 1:500.

Carbolic acid is recommended for disinfection in the strength of ten per cent. The crude acid may be used as it is just as effective and one-third cheaper than the purified acid. The odor, while not agreeable in the sick-room, is not nauseating, and is not so bad as that of chloride of lime, and the substance does no harm to the plumbing, so that practically it has come into more general use for the purpose under discussion than any other disinfectant. It is the one in common use in the large New York hospitals, where several hundred cases of enteric fever are treated every year.

Chlorinated lime, which contains from 25 to 40 per cent. of available chlorine, is a very cheap and efficient disinfectant when used in large quantities. Its odor constitutes the chief objection to its use. If the patient does not object to the odor, a quarter of a pound may be placed in the bed-pan before each stool. Otherwise the stool may be received into a pint of a ten per cent. solution of carbolic acid, and then later an equal bulk of chlorinated lime is to be stirred into it. The latter, as compared with carbolic acid, is only superior in being less poisonous.

A four per cent. solution of chloride of lime contains from 1 to 1.5 per cent. of available chlorine. The Labarraque's solution of chlorinated soda, although somewhat stronger in chlorine (2 per cent.) possesses no superiority and is more expensive.

Milk of lime, or "white-wash"— lime in solution and suspension — is a good typhoid disinfectant, but being much slower in action than either chloride of lime or carbolic acid, it is less desirable for bed-

side disinfection than for use in privy vaults and latrines. One part of freshly burned calcic hydrate in eight of water will require about two hours for thorough germicidal action. Although it does little or no injury to plumbing its particular value is in disinfecting privies where typhoid stools are thrown, and each stool should be thoroughly covered with a large quantity of the disinfectant.

The use of *iron sulphate*, as recommended by Budd, is inexpensive, as it costs but about four cents a pound, but it is not a disinfectant of any strength, although it is a good deodorant. It should not, therefore, be relied upon where so important a germ as that of enteric fever is concerned.

Formol, or formalin, has lately been recommended as a suitable disinfectant and deodorant for enteric stools. It is used in a 1:20 solution and has the advantage of being non-corrosive.

The difference in cost of the disinfectants above recommended is insignificant, unless they are to be employed upon a very large scale in epidemics. The following prices are quoted from Squibb's Semi-annual Price List, No. 77, 1897. The prices are given per kilogram (2.7 lbs.): Chlorinated lime, 50 cts.; ferrous sulphate, 55 cts.; crude carbolic acid, 65 cts.; corrosive sublimate, $2.61. Thus, while corrosive sublimate is more than five times as expensive as chlorinated lime, it is used only in 1:500 and 1:1,000 solutions, which makes it really much cheaper than any of the other disinfectants. Again, crude carbolic acid is more expensive than chlorinated lime or iron sulphate, yet it is used only in 1:10 or 1:20 solutions, which makes it cheaper. The cost of impure hydrochloric acid, to use with corrosive sublimate, is also trifling. From these statements it follows that, if expense alone were to govern the choice of one of these disinfectants, it should decide in favor of corrosive sublimate.

According to Huppe, the typhoid bacilli, being anærobic on first leaving the body, are more easily killed at once than later. Murchison and Calsy claim that the bacilli require one or two days to become infective after leaving the body, but this is probably an excessive estimate, for bacteriologists disagree in regard to this point, so that, no matter what disinfectant is selected, it is safest to keep a solution of it always in the bed-pan ready to cover the stool the moment of its discharge. Any lumps of fecal matter should be immediately broken up with a stick which can be burned, or a glass rod which may be disinfected, so that by this means the disinfecting solution may permeate the entire stool, and the stool should always

be left soaking in the solution for fully two hours before being thrown away. If thrown into a sewer, or privy, or trench before the disinfectant has had time to act, the latter becomes weakened by dilution, or separated from the stool altogether.

DISPOSAL OF THE EXCRETA.

The final disposition of the excreta must depend upon such circumstances as the extent and character of the drainage system, and will vary in the country and city. Immediate burning of the stools, mixed with sawdust, is well enough in camps and villages if wood is cheap and abundant, but it is difficult and laborious to build a fresh bon-fire for each stool, and keeping the stools until several accumulate is undesirable. In large hospitals where furnaces are maintained the stools may be easily burned, but this necessitates carrying them about through the building, and every pail or other receptacle into which they are emptied, of course, requires additional disinfection. It is much simpler, and on the whole as well, to disinfect each stool separately and empty it down the ward water-closet or a specially constructed drain hopper, flushing it afterwards with abundant water. Care should be taken to prevent spattering in this manner, or in rinsing the bed-pan. Several years ago, two cases of enteric fever developed in my service at the New York Hospital among patients who had been confined to the ward much longer than the incubation period of the disease. Investigation showed that typhoid stools had been emptied down a drain in the ward lavatory, over which there was a water faucet. Contrary to rules, these patients had been drinking from this faucet, upon which particles of the dejecta might easily have spattered.

In seaboard cities where the drainage system empties directly into tide water, the problem of disinfection of the dejecta is less urgent than in the country. Upon inquiry at several of the New York hospitals, I find that the methods ordinarily employed are by no means theoretically perfect, the disinfection in many instances being quite superficial, but as the stools are promptly washed seaward through sewers into tide water, it makes but little difference to the community at large. However, every year in the late summer a few young men and boys of 12 or 14 years of age, are brought into the hospitals suffering from typhoid fever, who belong to too poor a class to have enabled them to visit outside the city. It is found that they

have been in bathing off the docks and close to the mouths of the sewers.

The question of possible typhoid infection from effluvia from ill-ventilated sewers or foul drains or cesspools into which non-disinfected stools have been emptied, has given rise to much discussion. In this country there has been of late years a rapidly growing tendency to decide the matter in the negative, and to regard cases of typhoid fever occurring in persons subjected to such noxious inhalations as coincidences merely, the germs having entered the system through some of the other manifold opportunities. In England, however, this theory still prevails to a considerable extent, and the statement appears in Stevenson and Murphy's Treatise on Hygiene and Public Health (vol. II, p. 320), that "there is no doubt that the air of sewers and drains which have become specifically contaminated, may, if allowed to find its way into dwellings through defective house connections, cause from time to time enteric fever among the inhabitants of such dwellings," and in support of this assertion, the writer of the article refers to recent English public health, "Reports on Outbreaks of Enteric Fever at Croydon, Worthing and York, by Drs. Buchanan, Thorne and Airy." The long latent period of typhoid fever under some conditions, and the difficulty of making thorough bacteriological examination of drinking water in connection with epidemics of this fever, may in part, at least, account for the prominence which the sewer effluvia theory of infection still assumes in the minds of some investigators, despite the weight of evidence against it.

In country localities the problem of disinfection is quite different. Here there is not only danger of water contamination from imperfectly disinfected enteric stools, but the soil itself in time may become infected. (Blyth.) There are many rural districts in this country in which a certain number of cases of typhoid fever occur with great regularity every year. Typhoid stools which have been incompletely disinfected, and which have not been deeply buried, but cast upon the frozen ground in winter, have been washed off in the spring into sources of water supply, and have caused extensive and disastrous epidemics.

Blyth says in his Manual of Public Health (p. 508): "A constant series of cases occurring regularly in the autumn among children would point to the probability of the soil itself being infected, for, as is well known, children sit about upon the ground, continually have earth-soiled hands, and in this way contaminate their food."

In the country in the absence of proper drainage or sewerage system and if cremation is not feasible, the stools should be disinfected thoroughly by chemicals and buried in a long trench at least four feet deep, and two feet wide. This trench should be remote from the well or other water source. The first stool should be emptied into it at one end, the others following in succession, each being promptly covered with a layer of quicklime and earth. Such a trench should never be allowed to become more than half full before it is closed, and the earth first thrown in, should be well beaten down.

A very common mistake in the process of disinfection in the country is the use of large quantities of water for cleansing bed-pans and other soiled articles. Although strict precautions are taken in other matters this water is sometimes permitted to flow away without disinfection, as, for example, when a pail is carried to the trench for the purpose of emptying a stool, and is thereupon flooded with several buckets of water which flow over the soil, scattering the germs about. It is better to use only the corrosive sublimate 1:500 solution, or the carbolic acid, 1:20 for such purposes, and not use more than necessary.

It sometimes happens that the disease is well advanced before the physician is summoned, and he finds that the patient has been making frequent use of a common privy. In this case the duty of the physician is not confined to disinfection of the subsequent stools, but the privy or cesspool already contaminated should be thoroughly disinfected with chloride of lime and cleaned out.

Disinfection of Articles Coming in Contact With the Dejecta or Rectum.

There are several important details in connection with the disinfection of particles of the stools which may come into contact with various receptacles or with articles introduced into the rectum.

(1) *The bed-pan.*—This should be, when possible, of porcelain, rather than of japanned metal or agate ware, because it is not roughened and corroded by disinfectants, and being white, it is easier to see any soiled spots upon the surface, and it furnishes a better background for examination of the stools in a search for blood, mucus or undigested food. After emptying the stool, the pan should be thoroughly rinsed with boiling water and wiped off with either a carbolic acid 1:20 solution or a corrosive sublimate 1:500 solution, and then partially filled with the disinfectant ready for immediate use. Any cloth used for wiping the pan should be subsequently burned.

(2) *The thermometer.*— Each typhoid fever patient in an hospital ward should have his own rectal thermometer, which must be disinfected immediately after use by wiping it clean upon a piece of absorbent cotton, to be at once burned, and the instrument should be left immersed in a 1:500 corrosive sublimate solution. I have been unable to find satisfactory proof that enteric fever may be acquired by introduction of the bacilli in this manner into the rectum, but even in the absence of positive evidence, it may be possible, and it is such a simple matter to prevent the accident that no excuse could be found for its occurrence. In a crowded hospital ward the interchange of rectal and mouth thermometers will sometimes take place in spite of rigid rules, and every precaution should be taken to disinfect those used in diseases which are infectious through the dejecta.

(*3*) *Rectal syringes and tubes.*— The same rules should apply to the use of rectal syringes used for enemata, whether laxative or nutrient, and for the long soft rubber rectal tube used for the relief of tympanites. The latter should be scalded, and immersed for two hours in the 1:20 carbolic acid, or the 1:500 corrosive sublimate solution. As a rule, syringes with metallic tips should not be employed in the rectum in these cases, owing to the local irritation which they sooner or later are apt to cause, but if used, the tip should be subsequently disconnected from the rubber bulb, and boiled for an hour before being used upon any other patient. Anderson reports two cases of typhoid fever which became infected through the careless use of rectal syringes employed upon other enteric patients.

(*4*) *The hands of the nurses.*— The hands of the nurses or attendants should always be thoroughly disinfected after handling either the bed-pan or any other of the appliances above referred to, or the body of the patient himself. They should be washed with soap and hot water, scrubbed with a nail-brush and immersed in a 1:1000 corrosive sublimate solution. This is especially important just before going to meals, when the infected fingers or nails may convey the germs to bread or other articles of food about to be eaten. Nurses should also take the same precaution after giving sponge baths or tub baths, because it is almost impossible to prevent some contamination of the surface of the patient's body, especially about the buttocks, if many fluid passages have occurred. There will be some spattering of the discharges about, and particles containing the germs will get

into the bed or upon the body. (Since writing the above, I have noticed that Dr. Tyson, in his *Practice of Medicine*, p. 45, suggests that infection of nurses may occur through administering tubbing treatment.)

The visiting physician should be similarly careful to disinfect his hands after examining the abdomen of the patient. It seems an unnecessary degree of precaution to disinfect the hands after examining each typhoid patient in a ward, as some insist should be done, but such patients may be seen consecutively, and the hands should then be disinfected before passing on to a case of a different order. The nurses should also be warned against the habit of putting their infected fingers to their mouths. I make it a rule to frequently renew these cautions to the nurse in each case, for their importance cannot be overestimated. I speak feelingly on the subject, for I am confident that I acquired the disease myself several years ago from neglect of this kind. I had been for over two months at my own home, where I had drank no water or milk which had not been boiled. Being on duty at two hospitals, I had been daily examining a large number of enteric fever patients, and I could account for the infection in no other way than that in handling the abdomens or backs of some of these patients I had infected my hands, and had failed to cleanse them sufficiently before eating. I have seen a number of cases among trained nurses and orderlies which were unquestionably acquired in a similar manner.

(*5*) *Door-knobs* which the nurse has handled immediately after touching the bed-pan or other infected surface, should be scrubbed with a 1:20 carbolic acid solution.

(*6*) *Disinfection of the patient's sheets, blankets, pillow cases, towels and night-clothing*, as well as underclothing worn prior to remaining in bed, should be thorough. All these articles when soiled should be soaked in a 1:20 carbolic acid solution (corrosive sublimate is apt to stain), and then rinsed and boiled in a large clothes boiler for fully three hours. In hospitals where a compressed steam disinfection plant exists, the clothing should be disinfected for four hours at a temperature of at least 140° F. Fitz and Wood (Practice of Medicine, p. 120), declare that enteric fever is very common among laundresses who have washed the clothing of patients having this disease.

(*7*) *The mattress*, even though protected, as it always should be by a rubber sheet, is liable to become soiled by the evacuations from

the bowels. It should always be well aired and made over, and if actually soiled it should be disinfected by the Health Board plant, or the naphtha renovating process in cities, but in the country it may prove best to burn it. Rubber sheets should be wiped with 1:20 carbolic acid solution, rinsed in hot water, and aired in the sun.

(*8*) *Flies.*—While undergoing disinfection the tools should be kept covered, and care should be taken to prevent flies from gaining access to any particles of either the moist or dry dejecta. It is well known that these pests convey tubercle and cholera bacilli upon their feet and even in their own intestines, and it is quite possible for them to spread typhoid bacilli about in the same manner.

(*9*) Another practical point concerns the possible *infection of the patient* from his own dejecta. Furunculosis is a very common complication or sequel of typhoid fever. It occurs sometimes even in patients who have been daily receiving the Brand tub baths and whose skin has been kept carefully cleansed. The furuncles may occur in any part of the body, but in my experience they are far the most common about the buttocks and thighs, and I have been inclined to attribute them in such cases to the patient becoming inoculated with the ordinary streptococci through scratches or abrasions of the surface. I saw four or five such cases during the past autumn at the Presbyterian Hospital. It seems highly desirable that the patient's anus, perineum and buttocks should be wiped off with a 1:2,000 corrosive sublimate or a 1:40 carbolic acid solution after each defecation, and then washed with hot water and soap.

(*10*) A possibility of infection arises in connection with the treatment by cold tub baths. In a crowded hospital service it is customary to change the water in the tub only once a day, or, on the average after giving six baths. It may be necessary to bathe more than one patient in the same water. Patients very rarely defecate in the tub. I have known but one instance of it in tubbing upwards of 250 patients, and this patient was having almost constant diarrhoea. But even without this occurrence, there must be many typhoid and other germs floating in such water, derived from the parts about the anus, some of which may conceivably be rubbed into an abraded surface of the patient's skin, and there is also danger of infection of the attendants. They are apt to get out of breath while rubbing the patient in the tub, and to breathe through their mouths while bending over it, and infected water is thus quite easily spattered in. It is, of course, easy to exaggerate this danger, but it seems a possible

way of accounting for some few cases I have seen among nurses and orderlies while carrying out the Brand treatment, although owing to the labor of analyzing water for typhoid bacilli, I have been unable to obtain any positive data in support of this hypothesis. In the country the problem of disposing of a large bath-tub full of infected water must needs be quite serious. Corrosive sublimate cannot be added to a metal tub, and other disinfectants would have to be used in enormous quantities to be of value in purifying so much water. The water might be boiled in separate quantities, but that would require unnecessary time and labor. Probably the best way is to pour the water slowly into a trench filled with chloride of lime. In any event it should be kept away from all fresh-water sources.

The explanation of the cause of relapses in typhoid fever is still undetermined. There is a growing tendency to regard them as not always due to absorption of the typho-toxin, but to some other form of toxin, possibly a ptomaine, developed in the alimentary canal. If they are due to re-infection of the patient by the typhoid bacilli, is it not possible that such reinfection may be established by the reintroduction of fresh typhoid germs which have been developing outside the patient's body? The relapses often occur at a time when the patient is first beginning to make more use of his own hands in feeding himself with bread, etc., and as no pains is taken to disinfect them he may conceivably convey fecal germs to his mouth by means of his own fingers. I do not propose this theory with any confidence, but it is difficult to explain how the typhoid bacilli within the bowels, which have been there throughout the disease that has run its course, should suddenly give rise to one and even two relapses. Could it be possible that fresh bacilli, reintroduced at this time, may possess greater virulence?

The problem of how long typhoid stools should continue to be disinfected is of practical importance. It is customary and proper to begin the disinfection so soon as the diagnosis is made, but how long should it be continued? It is a needless expense and bother to keep up the process longer than necessary. I have seen one typical relapse occur as late as the twenty-first day after complete cessation of the fever of the primary attack, yet some patients are able to leave the hospital by that time. As a rule, the disinfection should not be relaxed for ten days after the temperature first remains normal, and if a relapse occurs it must be continued under the same rule. Stroganoff found the bacilli in the stools twice on the ninth

day, and once, quite exceptionally, on the fifteenth day after reaching the normal standard of temperature. On the other hand disinfection should be begun as soon as possible in each case, for although the bacilli are rarely discoverable much before the ninth day of the fever (Karlinski), it is better to err upon the safe side, and the date of actual onset of the disease is not always easily determined.

After death from enteric fever a plug of cotton, saturated with a 1:10 solution of carbolic acid should be inserted in the rectum, and the buttocks should be enwrapped in a three per cent. solution of the same to prevent any possible leakage of fecal matter.

CONCLUSIONS.

1. The best disinfectants of typhoid stools for practical use are (1) a 1:500 acidulated solution of corrosive sublimate, (2) a 1:10 crude carbolic acid solution, (3) chlorinated lime.

2. Owing to the possibility of injury to plumbing, the carbolic acid solution is preferable wherever plumbing is concerned. The lime is best for country use in privies and trenches.

3. The disinfectant should be thoroughly mixed with the stool and left in contact with it for fully two hours. Enough of the disinfectant must be added to completely cover the stool with the solution.

4. The bed-pan should be kept ready-filled at all times with at least a pint of the disinfectant into which the stool is at once discharged, and should be cleaned with scalding water and one of the disinfecting solutions.

5. Rectal thermometers, syringes, tubes and all utensils coming in contact with any of the fecal matter must be disinfected with the corrosive sublimate or carbolic acid solution.

6. After each stool the patient's perineum and adjacent parts should be washed and sponged with a 1:2000 corrosive sublimate solution.

7. Nurses and attendants should be cautioned to wash their own hands thoroughly and immerse them in a 1:1000 corrosive sublimate solution after handling the bed-pan, thermometer, syringe or patient, or giving sponge or tub baths.

8. All linen and bed-clothing used by the patient should be soaked in a 1:20 carbolic acid solution and subsequently boiled for fully two hours.

9. Disinfection of the stools should be begun as soon as the diagnosis of enteric fever is established, and should be continued for ten days after the temperature has remained at the normal.

10. In localities where a proper drainage system is lacking, the stools should either be mixed with sawdust and cremated, or buried in a trench four feet deep after being covered with chloride of lime.

34 EAST THIRTY-FIRST STREET.

XIII. DISCUSSION ON PAPERS ON THE POLLUTION OF WATER.

BY PROF. WILLIAM T. SEDGWICK,

Consulting Biologist of the State Board of Health, Massachusetts.

Owing to the lateness of the hour, I will say only that it gives me great pleasure to stand here as a representative of the State Board of Health of Massachusetts, and the more so because within the last few years that Board has made extended investigations regarding the ætiology of typhoid fever, especially in connection with drinking water, and has conducted a series of experimental investigations at Lawrence, Mass., upon the purification of water and sewage, which have become almost classical.

I wish to express, also, my great gratification to find that the State Medical Society of New York has given its attention to these matters, and my congratulations that there has been presented to-day so valuable a symposium of papers upon the subject under consideration. Within the last six years I have myself personally investigated fifteen outbreaks of typhoid fever, from an epidemiological point of view, and can heartily endorse all that has been said in regard to the difficulty of detecting the germ in water, milk, or wherever it may be. Nevertheless, I think that a good deal of progress has been made in our interpretation of phenomena, all of which has been so well stated in the papers that I shall not undertake to go over the ground. One or two points which have not been touched upon, however, I would like to mention.

In the first place, let me remark that there are some as yet little recognized sources of contamination of water. Some have not been mentioned in the papers. One of these is bathing in, or boating, or fishing upon, reservoirs or lakes from which water is drawn for drinking. A special investigation was made in Massa-

chusetts during the past summer concerning possible infections of water supplies by picnickers, bathers, etc. The results were instructive and interesting. There was also an epidemic of typhoid fever in the city of Haverhill, which has a population of about thirty thousand. At first we were unable to trace the source of the epidemic. The people were sure that the water supply was all right, that the milk supply was pure, etc. Finally we were forced to conclude that the disease was connected with one of the water supplies. We were assured that this could not possibly be contaminated, yet on going to the lake every evidence was found of the constant use of this reservoir as a picnic place. Defecation had taken place along the shores, even very near the gate-house, and there was good reason to believe that a low class of people who went there on picnics bathed in the lake. It was easy to imagine, and it was also probable, that pollution had taken place in that manner and caused the mild epidemic of typhoid which had distributed itself along this particular water supply.

Another peculiar case — I pass over the more ordinary ones because they are familiar to you all — illustrating how people may foul their own nests, so to speak, occurred at a lake to which an electric railway, or "trolley," carried several thousand people almost every day. Every day a different set of people attended, so that within a month, perhaps almost a hundred thousand persons might go to the lake and be exposed to whatever pollution of the water-supply was taking place. Privies were found on the grounds contaminating the lake from which the authorities drew the water supply by pipes carried out only about one hundred feet from shore.

I wish to express once more my personal gratification at having been present at this meeting. It seems to me that it is along the lines indicated to-day that progress must come. We know now that typhoid fever may be carried by impure water. We know, also, that impure water can be purified, and in this connection I would like to say that in the city of Lawrence, with a population of fifty-two thousand people, typhoid fever was formerly abundant. It was a common thing on going through a street to learn of a dozen cases, and the reason was that they drank water polluted with sewage which came down the river from Lowell and other points above Lawrence. To-day, with simple, natural, sand-filtration of the water all — the first of the kind in the United States, and giving readily the water needed — typhoid fever has nearly disappeared from the city.

Finally, I wish to express the sense of pleasure I have had in listening to the valuable critical paper of Dr. Carpenter. It seems to me that he has reviewed the matter thoroughly; has weighed it well; has presented the strong and the weak points of the case, and made his paper one which ought to be read by every person who has to do with the purification of the water supply cf great cities.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON.

State Medicine.

EDITED BY HARRY SEYMOUR PEARSE, M. D.

An Additional Hospital for Criminal Insane. — A bill has been introduced in both branches of the legislature appropriating $125,000 for the erection of a hospital for insane convicts in connection with Clinton Prison at Dannemora. Last year $25,000 was appropriated for the same object and the foundations have already been laid.

The Matteawan State Hospital is at present very much overcrowded and contains nearly 600 patients. This hospital will be relieved of the care of insane convicts when the new buildings are completed.

The institution at Matteawan receives patients from the courts who are charged with crime, but who have been adjudged insane and who remain unconvicted. It also receives patients from all the penal institutions of the State whose insanity arises or becomes apparent after sentence and during confinement. The large majority of these latter cases are habitual criminals, and it is proposed to separate them from the court or unconvicted cases. Many of them are vicious and accustomed to criminal ways and to immoral practices. Their insanity does not hold a causative relation to their crime, but arises subsequent to its commission. The majority of them have chosen a life of evil-doing of their own free will. By heredity and by environment they constitute a dangerous class of professional criminals. On the other hand, the court cases, for whom it is proposed to reserve Matteawan, are not of the criminal type.

While, as a rule, they are a very dangerous class, on account of their delusions, nevertheless their criminal act is the product of their insanity, and they are not vicious or immoral in their habits. The crime for which they are confined is, perhaps, the single criminal act of their lives, and they have been led to its commission by reason of mental disease.

The great majority of them have committed crimes directed against human life, usually acts of homicide or dangerous assaults, to which they have been led by ideas of persecution, and which render them a constant menace to society when at large and to their custodians when in confinement. They are held to await the action of the courts pending their recovery.

The capacity of the Matteawan State Hospital when first erected was supposed to be sufficient for several years; but by reason of the operation of the State Care Act and other changes in the statutes, which directly and indirectly affected this hospital, its population has rapidly increased, with every prospect of continuance. It is now proposed to build in connection with Clinton Prison a modern hospital for the care of insane convicts while under sentence. The buildings are to be entirely detached from the prison, and of a sufficient capacity to accommodate 300 inmates, with provision for enlargement. The structures, as at present planned, comprise an administration building, a central structure containing a kitchen, bakery, large congregate dining-rooms, a chapel and a hospital, together with six adjoining wards. The buildings are to be of stone, fire-proof, and are to be erected by convict labor.

There are several reasons why Dannemora has been selected as the place for this institution. A less remote location would at first seem better. The class to be confined there are vicious, dangerous, crafty, difficult to manage and ever ready to escape. Many have homicidal tendencies, are perfect demons, and once having obtained access to a crowded community could perpetrate heinous crimes before capture, whereas at Dannemora the surrounding country is thinly settled, the place remote and the danger minimized. There, also, fewer sensational and harmful stories would find their way into the papers.

New York is in advance of her sister states in having such a hospital as Matteawan. Recently Pennsylvania and Connecticut have sent commissions to that institution to learn its workings and to submit reports and recommendations. Both states have felt the great need of a hospital of its kind, and each will, doubtless, soon have one. And we hope that Matteawan may be used as an example.

This new hospital at Dannemora will constitute a valuable addition to the already admirable system of care and isolation of our criminal insane.

The bill has passed the assembly, but with a reduction of $50,000, making the appropriation now $75,000, an amount wholly inadequate

for the completion of the plans. We regret the "pruning," yet must be satisfied for the present with the amount given if the figures remain unchanged till the bill passes the executive.

The Craig Colony Appropriation. — There has recently been introduced in the assembly a bill entitled, "An act making an appropriation for the Craig Colony for Epileptics." It provides for the setting aside of a sum amounting to $182,300 for the purpose of erecting buildings upon and grading the land now occupied by the colony, in other words, to establish proper facilities for the perpetuation of a work already begun.

The colony was founded in 1894 at Sonyea, N. Y., and since that time the patients have occupied the old buildings of the Shakers, from whom the land was purchased by the state. These buildings are wholly inadequate and improper in construction for the purposes of the colony, which is in every sense a hospital.

The colony system for the care and treatment of these unfortunates was inaugurated in France forty-six years ago, and in Germany twenty years later. The success of the method is unquestioned. Formerly the ultimate end of an epileptic was almost always dementia, whether he be confined to an institution and treated with cases representing all types of insanity or allowed his freedom. The records of these colonies show complete recovery in 6 per cent. of all cases and improvement in 60 per cent. The system has accrued to the moral, mental and physical betterment of an unhappy class as no other system or method of treatment. Insane epileptics are not included in the class treated; thus the patients are not forced to look upon epileptic dements with a realizing and horrifying sense of their possible future condition as they are in state hospitals.

The patients of Craig colony are not wholly dependent upon the State. There are some private and semi-private cases. And the product of their work for the fiscal year ending September 30, 1896, netted a sum equal to 50 per cent. of the sum necessary for their maintenance.

A large-hearted governor and legislature took the initial step in this reform by purchasing the land and establishing the colony, and it seems to me to be the duty of their successors to maintain it. The present appropriation is necessary to do it in the proper manner and according to the idea of its founders. Within the past ten years the state has made gigantic strides in alleviating the sufferings of its insane element. It has done away with the horror of the alms-house

as an asylum, and changed its big institutions from prisons for the confinement of the insane into hospitals for their treatment. The establishment and sustenance of this colony is but a phase of the great and grand reform, and should, therefore, be passed by both branches of the legislature and approved by the governor.

A Bill Providing for an Investigation of and a Report upon the Sources of Water Supply in this State. — Senator Brush, on February 2d, introduced a bill of great importance under the following title, "An act constituting the State Board of Health and the State Engineer and Surveyor a water board to investigate and report upon the sources of water supply in this state, and as to what means may be necessary to secure water in a pure state for use in the principle cities and towns, and for use in the canals in the state, also to provide for the necessary surveys and making an appropriation therefor."

This bill is directed mainly toward a complete survey of the water sheds of the Adirondacks with the view of furnishing a wholesome and abundant water supply to the cities in the Mohawk and Hudson valleys and southern portion of the state if possible. The survey would be but the first move in a gigantic enterprise, should it prove the possibility of obtaining water in necessary quantities and of desired quality from this source. And, as stated by a member of the New York State Board of Health, it would be worth $40,000 — the amount appropriated for the purpose — to the state, to know whether water could be obtained from such a desirable source.

It is an indisputable fact that the impure waters of the Mohawk and Hudson rivers add greatly to the mortality rate in this state each year. The state mortality report for 1896 shows that 1,600 deaths were due to typhoid fever, "the highest number being in the southern tier and Hudson valley."

The citizens of the city of Albany are now discussing a plan for the construction of a sand filtration plant, recognizing the necessity of purifying in some manner their water supply, which is taken from the Hudson river, and it would not seem advisable for them to discontinue their efforts, awaiting any action of the state towards a general supply in the remote future from the Adirondack lakes and streams.

We hope that Senator Brush, who is a physician and appreciates the necessity of some radical move in this direction, may be successful in his efforts to get this measure through.

The Appointment of a State Veterinarian. — Under the title "An act in relation to the appointment of a state veterinarian, and defining his duties," a bill was presented in the Senate, January 22, and provides as follows:

1. That the governor, with the advice and consent of the senate, shall make the appointment; the term of office three years, and the appointee shall be a regularly graduated veterinary surgeon, having practiced not less than ten consecutive years in the state; that he shall be a member of the State Board of Health, and that his compensation shall be three hundred dollars per month and expenses.

2. That he shall investigate any and all cases of contagious or infectious diseases in the lower animals, in any part of the state, reported to the State Board of Health or commissioner of agriculture, and direct the management thereof and enforce the laws relating to these diseases.

3. That all cases of tuberculosis in animals shall be put in his charge, and it shall be his duty to investigate them, assume responsibility of and report upon them.

It is certainly true that the state is very much in need of the enactment of some measure which will give it complete control of all infected animals within its borders. As it is at present, whenever a case of the infection of human beings through animals presents itself, the city or county health authorities must manage it, and this always leads to delay and endless litigation, as in the recent case of investigation into the scarlet fever epidemic in Albany and the praiseworthy endeavor, at the same time, of the local board to establish an organized crusade against tubercular infection through milk. Strong opposition was immediately encountered.

This bill is an admirable measure as far as it goes, but it does not go far enough. One man could not, under the conditions existing at present, take care of this department. Our state holds no restriction whatever against the constant inflow of tubercular cattle to its territory. States surrounding us guard every gate where cattle enter their precincts with an inspector who tests each head for tuberculosis. And we are told that many heads of cattle that are judged tubercular by them are thrown back into our State. Under such conditions it would be manifestly impossible for one man to fight this one disease alone with any degree of success. The state should have all cattle entering its borders examined for tuberculosis at the points of entrance.

Here is but another cry for the necessity of a fountain head of State hygiene with an official bacteriologist and chemist, a well equipped laboratory and expert inspectors, both medical and veterinary. Berlin has such an institute, and there is no reason why New York state should not have one. It should be under the control of the State Board of Health, then that department of the state government would have the available means for carrying on its most important work, which at present it certainly has not.

The Optometry Bill. — No measure relating to state medicine, so far presented in this session of the legislature, has brought forth anywhere near the opposition that this so-called optometry bill has met with. From the moment of its introduction there has been a constant and vigorous fight against it. And it is safe to say that every medical society and association in the state, every journal which pretends to guard the welfare of the medical profession and the people, every oculist of good standing and every reputable optician, is strongly opposed to it.

So far the bill has been given two hearings before the assembly committee on General Laws. At each hearing vigorous pleas in opposition were heard, by Drs. Wynkoop and Marlow of Onondaga county, both representing medical societies, at the first hearing, and at the second, by E. B. Meyrowitz of New York city, and A. White of Buffalo, prominent opticians; Dr. A. Walter Suiter, representing the State Medical Society ; Drs. Callen of Westchester and Marlow of Syracuse, Drs. Van Fleet and Mittendorf of New York city; Drs. Ward, McDonald, Bendell and Cox of Albany.

Their objections to the bill were chiefly as follows: That none but practicing physicians were competent to advise and prescribe for diseased eyes; that there was great danger to the public from irresponsible persons attempting to adjust glasses; that it would license to practice upon an ignorant public a large class of designing and unskilled men who know nothing, and are not required to know anything, about the diseases of the eye, or the underlying pathological conditions of the body which are often the direct cause of derangements of vision.

We are at a loss to understand how the committee or legislature can conscientiously favor such a measure, and should the committee report it favorably, the legislature should promptly vote it down in the interests of humanity.

The New York State Civil Service Commission will hold open competitive examinations for medical positions in the State service April 10, 1897, notice of which is printed on another page.

Obituary.

ALBERT WELLS KILBOURNE, M. D.

Dr. Albert Wells Kilbourne was born in Liberty, Sullivan county, N. Y., July, 1850. He was educated at the Peekskill Academy and received his medical degree at the University Medical College, N. Y., 1874. He was house-physician at St. Peter's Hospital, Albany. Among the positions held by him were assistant to Eye and Ear Dispensary, Albany Hospital. He was also on the surgical staff of the general dispensary. For several terms he filled the district physician's appointment, and for four years was a U. S. pension examiner.

He died January 14, 1897. Dr. Kilbourne was a faithful, painstaking, skillful practitioner, and is missed by many to whom he was both friend and helper. L. B. W.